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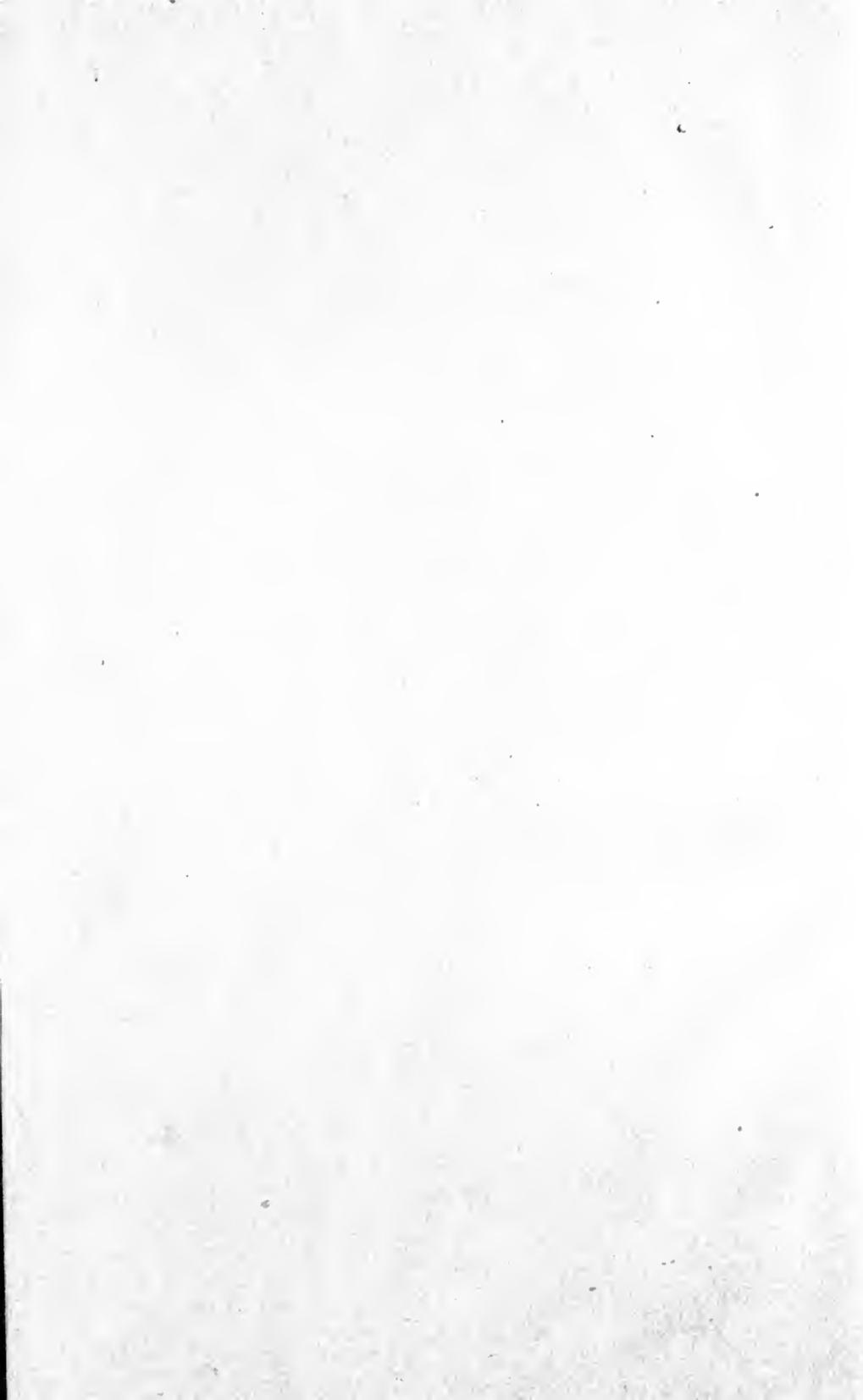
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CITY OF BOSTON.



REPORT . . .

OF THE

COMMISSIONERS ON INVESTIGATION OF WATER SUPPLY.

IN COMMON COUNCIL, Feb. 15, 1883.

To the Honorable the City Council: —

The Commission appointed in September last, to whom was referred the petition of Henry J. Barnes and others, asking for an investigation of the water supply of the city, would respectfully submit the following

REPORT:

Although the terms of the order under which the Commission acted were sufficient to warrant an examination of all the sources from which the city derives its water, yet, as there has been no recent public manifestation of discontent with the Mystic supply, and as it was not alluded to in the petitions referred to the Commission, it has not been included in the investigation.

In endeavoring to arrive at a proper conclusion in regard to the Cochituate and Sudbury supplies the following course was adopted: Hearings were first given to the petitioners, and the Water Board and the City Engineer were then requested to make such statements as they desired. The Commission then called before them the various experts in the vicinity who were specially familiar with the subjects in question, and, as the testimony given by several of these gentlemen is of great interest, and should be preserved, it has

been decided to submit it as an appendix, where it may be examined by those who wish to satisfy themselves in regard to some of the reasons which have influenced the Commission in making this report.

The sources of supply have been carefully examined, and also the sources of pollution. Other large cities have been visited, to obtain information in regard to the causes of the various troubles from which they also had suffered.

It is a matter of regret that it has been necessary to delay for so long a time a report in which the community has so deep an interest; but the consideration of the supply of water to a large city opens so many difficult questions that a still longer period might advantageously have been employed.

The Commission, however, having unanimously agreed upon the principal points before them, present them at once, believing that their opinions will bear the criticism of all who carefully investigate the subject.

The supply of water in Boston from the Sudbury and Cochituate systems is about 32 millions of gallons a day, of which about 20 millions are commonly taken from the Sudbury basins and about 12 from Lake Cochituate, though the latter quantity is more than the lake can be counted on to always furnish.

Lake Cochituate is a fine sheet of water, with gravelly shores, and if unpolluted and properly cared for is as good a source of supply as any city could wish to possess. As, however, the chief cause of trouble has arisen in the Sudbury river, that subject will first be considered.

The Sudbury is a small river, starting from Whitehall pond, in the town of Hopkinton, and running eventually into the Concord river. Its flow varies from almost nothing in a time of drought to hundreds of millions of gallons a day in the early spring. The water must be stored at that time, and preserved until wanted, at some later date; and it is to this fact that much of the trouble is due. No purity of supply or preparation of basin seems to be able to thoroughly protect a large body of stagnant water when exposed to the summer heat. At the same time the troubles experienced may be considerably modified by proper precaution. Given a large body of quiet water, the best way to promote the growth of *algae* and similar aquatic plants is to store the water in a pond so shallow as to allow it to become thoroughly heated to the bottom, and have that bottom composed of a thick layer of vegetable mould. Although the basins on the Sudbury river are sufficiently deep in the centres to keep the water tolerably cool, yet in each of them there is a large quantity of shallow flowage, where the conditions

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referred to exactly obtain. It is true that the experience of Boston is only that of many other cities which have suffered in the same way. It is true, also, that it is only from experience that wisdom is learned, and that it is much easier to say what should have been than to say what ought to be ; for, if prophecies were made of future trouble when the basins were built, they did not carry conviction with them. The fact is now unquestionable, in the judgment of the Commission, that the only way to properly construct a basin is to take the loam *all out*. Circumstances might be such that other means would have to be devised to accomplish the same result at a less cost, but no basin could be considered properly prepared for use in the near future which did not remove or entirely cover up all decaying loam. If a basin is not wanted for a number of years the loam might then be allowed to remain. A pond so constructed will annually work and ferment until all vegetable matter has been absorbed and carried off, and in course of time it will assume the condition of a natural basin ; but the length of time that this will require is so uncertain that no city can afford to wait for its accomplishment by natural means. On the Sudbury river the basin from which this sort of trouble chiefly comes has greatly improved since first put in use. Its fermentation comes every year at a later date, and before many years the body of the basin will probably be in good condition ; but the shallow portions must either be materially deepened or abandoned altogether, if any permanent and thorough improvement is to be anticipated.

There are three causes of complaint in connection with this water : first, *Algae*; second, *Spongilla*, or the fishy taste ; third, the presence in the water of more organic matter than is proper for good drinking-water. The *first* has already been spoken of. It is liable to find its way into still and warm ponds, no matter what may be the sides or bottom ; but it flourishes more abundantly in shallow water, and grows luxuriantly in Basin 3, or similar reservoirs. It has been seen on the borders of Basin 2 ; but the great quantity of water rushing through Basin 2, in the spring of every year, probably carries away most of the spores which may have been deposited, and the current of the river is much stronger than that of Stony brook, on which Basin 3 is situated, and prevents that condition of absolute quiet which is so advantageous to their growth. Basins 2 and 3 are identically constructed, and yet the water in Basin 2 has, practically, been as free from *algae* as that in Basin 3 has been filled with them.

Second. — The *Spongilla*. To this, the disagreeable fishy taste is probably due. The Commission are, of course,

produced. For this there is no remedy except time to recover, and extermination whenever found.

Algæ have been always observed to some extent; but these have probably come from the shallow flowage, by which the storage capacity of the lake has been increased, and have never affected the whole body of water to any such extent as to call for public remonstrance.

The sewage contamination to which the lake is exposed, however, is so grave a matter as to demand immediate action. It is impossible to present too strong a protest against the existing condition of affairs. It is true that chemical analysis is again powerless to demonstrate the effect of sewage which has been poured into a water supply in comparatively small quantities and at a considerable distance. Medical testimony is, however, practically unanimous, as to the peril of even a very small quantity of healthy human sewage, and it is perfectly clear on the point that the germs of disease which are contained in the discharges from the sick never lose their danger, even when greatly diluted or borne a long distance. They cannot be found in water by analysis; but they are there, and if, by chance, they find in a human body the proper condition for their development, disease would probably ensue. An outbreak of cholera or typhoid fever in Natick would be looked on with great anxiety by the physicians of Boston. It would seem as if there could be no question on the part of anybody as to the danger arising from the pollution of drinking-water by human sewage, and, so far as the Legislature of this State has acted, it has always been in accordance with this principle.

The Commission believe that no man has the right to defile the water supply of a community, and it is the imperative duty of city authorities to prevent and punish such pollution.

It is, nevertheless, the fact that, in spite of earnest efforts to remedy this evil, means have been found to evade the law as it now stands. Something, however, must be done. If the law advisers are of the opinion that no existing law can be enforced against offenders, there are three courses open to the city: First, to strenuously endeavour to obtain the passage by the Legislature of such a law as shall enable the city to protect its supply against pollution, whether caused by a town sewer, a prison of the Commonwealth, or a manufactory. The city is undoubtedly willing and ready to pay for all vested rights of drainage, if any such exist, but ought not to be driven to the second alternative of caring for all the sewage which threatens to pollute its sources of supply. To do this would not only abandon a principle which is in accord with the settled doctrines of the common law and all

modern legislation on the subject, but would also subject the city to great and constantly increasing expense.

Third, to abandon the supply. This would be a misfortune, for it is impossible to find a source naturally better than Lake Cochituate; but if the present condition prevails, and the water is to be polluted with impunity, it will, at no distant date, become entirely unfit for drinking purposes.

The recommendations which the Commission make for the Cochituate are :—

First. — To abandon all shallow flowage where the water is less than eight feet deep, and remove what loam there may be in water of that depth.

Second. — To thoroughly cleanse the Cochituate aqueduct every year, to ensure the removal of the sponge.

Third. — To prosecute without delay the people now polluting our supply, or else, if in the opinion of eminent counsel the present statutes are insufficient, to seek legislative relief. In spite of the protests which would be made by communities interested in polluting water, which they do not drink themselves, the Commission feel that the Legislature of Massachusetts will be found willing to enact the necessary laws, provided the futility of the present ones can be shown.

It has also been brought strongly to the attention of the Commission that a scientific examination, extending over a term of years, would probably furnish facts of much value to the city. They, therefore, recommend the engagement of some competent person by the Water Board, whose duty it would be to make periodic examinations for a term of years and report the results to the City Council.

JOSEPH CALDWELL,
MALCOLM S. GREENOUGH,
NATH'L J. BRADLEE,
JOHN G. BLAKE,
HARVEY N. SHEPARD.



APPENDIX.

REPORT OF THE HEARINGS BEFORE THE SPECIAL COMMISSIONS TO WHOM WAS REFERRED THE PETITION OF HENRY J. BARNES AND OTHERS FOR AN INVESTIGATION OF THE CONDITION OF THE WATER SUPPLY OF BOSTON.

FIRST HEARING.

WEDNESDAY, October 4, 1882.

The Commission met at 4 P.M., Alderman Caldwell, Chairman, and all the members present.

The Clerk read the call, and the Chairman announced that the Commission were ready to hear any suggestions.

STATEMENT OF DR. HENRY J. BARNES.

Dr. H. J. Barnes. — I do not know that I fully understand the scope of this inquiry ; whether it is admitted that the condition of the water has been such as to give cause for reasonable complaint ; or whether you seek to get opinions from people as to the cause of the difficulty.

The CHAIRMAN. — The intention of the Commission is to get all the information that there is in regard to the water supply.

Dr. Barnes. — It was only last evening that I received a notice of this meeting, and I have not arranged for a hearing, as I should have done to meet the case, had I received earlier notice. But if you think well, I will read to you the expressions of some of the gentlemen who signed the petition.

But, in the first place, I wish to call the attention of the Commission to the activity of the spring water-carts about the city for the past two years. Nobody can dispute that there has been an unusual sale of spring-water in Boston, and as the author of the petition presented to the City Government asking for an investigation, I obtained some signatures ; but many gentlemen interested in the subject carried the petition about themselves, such as Kidder, Peabody, & Co., Jordan, Marsh, & Co., Harvey D. Parker & Co., and others. Mr. Punchard, of the firm of H. D. Parker & Co., when I presented the petition to him, said he hoped something would be done, as it was costing them something like a hundred dollars a month for spring-water. At Lewis Coleman & Co.'s the young men had clubbed together to buy spring-water, claiming that the water they received from the city was unfit to drink. Jordan,

Marsh, & Co. took the petition and carried it about, and obtained signatures in their place and about the city. Mr. Barnes, of the Hotel Brunswick, stated to me that I could not state the grievance too strong to the authorities, for the "water had not been fit to bathe in much of the time for a year on account of the odors which came from it."

Mr. GREENOUGH.—Did he say that he furnished his guests with spring-water to bathe in?

Dr. BARNEŠ.—No, sir. He said he did not consider it fit to bathe in. The proprietors of all the hotels I saw about this petition signed it with but one exception, and they said they did not care a d—n about the water, as they sold rum, and not water.

It would hardly seem necessary to call your attention to the condition of the water-tanks at the tops of the houses in the city. I looked into many on Marlborough street, last winter, and found the bottom covered with a material—a sediment—of from two to two and a half inches deep. In the house I live in I found this material three-quarters of an inch deep in the bottom of the tank, and taking it out put it in a glass jar, and there is nothing I can compare it to for disgusting odor. Mr. Reed, of the Boston Ice Company, said to me that "his tank was filled to such an extent as to stop the flow of water, and that he was melting ice for drinking purposes, and he had been doing so for months."

Then, in regard to associating the odors perceived here with the odors in Farm pond. I have passed that pond frequently and noticed that the stench was most disgusting, indicating that a large amount of decay was going on there. Mr. A. W. Brigham, at 14 Sumner street, riding with me, said "What a smell this is!" as we were passing Basin 3 on the north division of the Old Colony Railroad. Mr. W. G. Lewis, of Framingham, said "that at times he could not remain there, its smells were so bad." Mr. Pope, of Leominster, has also noticed the stench coming from Basin 3 and Farm pond during the past summer. I had a conversation with a plumber on the Back Bay, who said his business had increased five-fold in cleaning tanks, and he had been kept very busy indeed cleaning them out where the material had deposited. Dr. Oliver Wendell Holmes stated to me that he had not drank any city water for two years; and many people on the Back Bay stated the same thing.

I cannot think it mere sentiment which prompts people to buy spring-waters. I see four or five different companies busy furnishing the people with spring-water. No longer ago than this morning I happened to be in a neighboring house, and the lady said to me, "Isn't the water getting bad?" as she had noticed the smell from the hot water. Another person I met in the car on my way here said the same thing. There has not been a time this year, when I have drawn hot water from the faucet in my house, that there has not been a stench. It is not so bad at all times. Since I have returned to Boston this fall I have been compelled to buy spring-water; and it is getting to be something of a tax to add to that regularly collected in advance by the city.

Last August I visited Basin No. 3, in company with Dr. Baker of this city, and Prof. Rice of Annapolis, and some other gentlemen. We were surprised. Mr. Rice, not knowing the topography of the country, spoke of the smell long before we came in sight of the basin. We went to one of the gate-houses and lifted the traps, and there was a stench like that from a sewer. I do not know that I ought to speak of this, as it might injure the man in charge ; but he said he was surprised that the people of Boston would drink such stuff ; that he did not any more think of drinking it than anything in the world ; and that he was constantly kept busy polishing the brass over these traps. This was the gate-house at Basin No. 3, and the time was last August, two months ago. Dr. Baker said he would not bathe in it, and a lady said she did not think it was fit to be used for washing. It was a time when the gates were raised for the water to be run into Farm pond.

It seems to me the trouble has arisen chiefly in this basin ; and that its purification has been sadly neglected. Mr. Remsen reported it as smelling of the "pigpen," in his investigation, and that no *spongilla* has thus far been found there. I have given special attention to this basin, and it seemed obvious enough what was giving rise to the trouble there. Of course you all know the extensive territory flooded, in the soil and lands of which must necessarily have lived and died vegetable matter, which, decaying, would vitiate the water, as flowers do in a vase. About every year since the basin was built, there has been more or less complaint about the taste of the water. Before it was used — some seven years, I think — the water of Stony brook and Sudbury river was used by the city, through Farm pond and Lake Cochituate, without trouble ; and it seems to me wrong to ascribe the water troubles to Farm pond, which I have known from my childhood to be pure and clean, as the bottom could be seen from many parts of the surface. I have boated there, and could see the clear rocks and sand several feet below the surface. In some parts it has a boggy or peat bottom ; but I have never known the water discolored until the water from the basins was turned into it. It is not necessary to detain you by going into the question investigated and reported upon so satisfactorily by Prof. Remsen, in relation to this pond ; but to associate his report with what Mr. Hyatt stated at the meeting of the Natural History Society, last winter, "that the *animalcules* were the chief substance upon which *spongilla* lived," and the statement in "Griffith & Henfrey's Micrographic Dictionary," that *algæ* are the principal nourishment for the *spongilla*, for both are found in great numbers in Basin No. 3, and, conveyed to Farm pond, nourish the *spongilla*. Mr. Van Veet found the *spongilla* distributed in that part of Farm pond which Mr. Wightman said was the natural channel between the two gate-houses. He found it chiefly about the upper gate-house. The effect of building the channel around Farm pond, last winter, was simply to transfer the growth of the *spongilla* to the walls of the new conduit ; for, in conversation, last June or July, with a man who had something to do with the cleaning out of the conduit, he said the walls were lined with *spongilla*, from South Framingham to Natick. You re-

member a complaint in the city last summer, some time in June, when Mayor Green visited the basins, and it was semi-officially stated that the trouble was somewhere between South Framingham and Boston.

I wish to say in regard to Farm pond, that you will find it in a different condition now from what I knew it to be before the Sudbury-river water was let into it. When the water was drawn off from that pond last winter I took pains to go around the basin and measure the depth of a fresh deposit of mud overlying the clean gravel. I found it about the banks of the new canal, varying in thickness from one to ten inches, and it seemed to be a fresh deposit, as it was filled with sticks, roots, blades of grass, and leaves. The peculiar condition of the banks of Basin No. 3 indicates this material was washed from them by the action of the waves taking in suspension this matter, and deposited in Farm pond. A great deal of it has been brought to Boston, rendering filtering so necessary, and to the tanks in our houses: at any time almost, we may hold up a glass of water and see it. I cannot see how it is possible for any one to contend that Farm pond could act otherwise than as a settling-basin for the great amount of material taken up from the banks of the ponds above. There are many reports in the Boston City Documents ascribing the cause of bad water to the decay of vegetable matter. Westboro', which has had trouble with its water, has lately received a report from the engineer employed, to the effect that it comes from shallow flowage of farm lands, resulting in decaying vegetable matter. Springfield has had trouble with its water, and the investigation showed that it was from decayed vegetable matter. Spot pond gave trouble some years ago, and has often been spoken of as an anomalous case. Mr. Wilde, of the firm of Lawrence, Wilde, & Co., and a member of the Water Board having this pond in charge, stated to me that there was no question of the cause of the difficulty there. "In a dry summer the mud bed of the basin had been laid bare, vegetation had sprung up, and the overflowing of it and its consequent decay had caused the trouble." The Water Board removed this mud as soon as possible, and they have had no trouble since. The investigation in Westboro' was reported three or four weeks ago, and was published in the "Westboro' Chronotype."

Last summer the Committee on Water, and other members of the City Government, made their annual visit to the water works, and many of them noticed what were called *animalcules* in the water; but they, being viewed with the naked eye, ought to be called animals, from their size; and their presence certainly indicates impurity of the water. From twenty to thirty are said to have been seen in a single glass.

It seems to me the condition of the city water is not what it should be. The water-carts are going about the streets selling water at ten cents a gallon, which is the price of cider. The proprietor of the Everett spring water-cart, standing in Hamilton place, this summer, must have taken from thirty to forty dollars a day. And yet there was a fountain near by where the people might have city water for nothing.

You see I have imperfectly prepared this communication, from the limited time I have had. I should have preferred to present my views in writing, that they might have been in better form. Nothing further occurs to me to suggest now.

MR. BRADLEE.—Do you know any injury to health caused by the use of the water?

DR. BARNES.—I cannot say that I do. I do know that we had an unusual number of cases of typhoid fever last year. I do not know that the Board of Health assigns it to impure water; but last summer the number of cases of typhoid fever was unusual.

Q. As I understand you, you attribute the whole cause to Basin No. 3?

A. Well, sir, I think the same causes operate in Basin No. 2, but not so strongly, in consequence of its banks being steep and effectively washed down to the clear gravel. There are no shoals left bare in Basin No. 2, as is the case of Basin No. 3 when the water is a little low; and this basin has been treated entirely different from Basin No. 3. Last year the mud bed of Basin No. 3 was laid entirely bare, except the little stream that trickled through it. On the other hand, Basin No. 2 was drawn down, but it soon filled by the considerable water flowing in the Sudbury, and, consequently, this water was fair.

Q. Do you know any difference between the high and low service as to its character?

A. I cannot say positively that I do, but what information I have on the subject is, that the high-service, which comes from Lake Cochituate, is good enough, and that the low-service, or Sudbury river, is what is complained of.

Q. How do you account for the difference?

A. It is only a matter of opinion, but I think the reason is that one is from Lake Cochituate and the other from Sudbury river.

MR. BRADLEE.—I would like to ask the Water Board if that is a fact.

MR. CUTTER (Chairman of the Water Board).—It is not.

DR. BARNES.—Was it not so last year, when there was complaint?

MR. CUTTER.—When we drew the water off from Farm pond, and shut off the Sudbury river altogether, Lake Cochituate was used by both services.

MR. GREENOUGH.—Dr. Barnes, what is your remedy for this difficulty?

A. I do not claim to be an expert on this subject, but it seems to me to make those basins of the character of natural ponds would correct the whole matter. That can be accomplished by cleaning the banks and removing the mud. It is a question in my mind whether the mud in the deepest parts of Basin No. 3 is a cause of the trouble. It seems to me it is the material brought into the water by the action of the waves that gives rise to the trouble, and the growth of the *algæ* on the mud banks.

MR. BRADLEE.—You do not think there is anything radically unclean in the source of supply, do you?

Dr. BARNES. — From what I know of Sudbury river and Stony brook the water is good enough. The artificial changes made there have caused the trouble, and it further seems to me the drainage of Natick has not had much influence upon the water supply. Mr. Remsen found the water in Lake Cochituate good enough. Therefore, I do not feel that this basin is at fault. In fact, all summer Lake Cochituate has been clear, and you could look into it at considerable depth; whereas in Farm pond you could not look into it three inches.

Mr. SHEPARD. — Are you acquainted with the sources of supply of Sudbury river?

Dr. BARNES. — No, sir.

Q. Or where it rises?

A. No, sir. Most of my information comes from the reports of commissioners and committees on the subject. Mr. Davis said the Sudbury-river water was used for bleaching purposes for many years, and that it had unusual purity. He advised the city to take it in preference to the Charles, on account of its purity. You know it was debated at considerable length by the City Government, and it was taken on account of its freedom from impurities.

Q. Your own opinion is, that, if we would get rid of the *spongilla* and *algae*, it must be done by making the basins as much like natural lakes as possible?

A. Yes, sir; I think it would. I think that the mud flats about Basin No. 3, where the crows have hovered for several years, and the unusual growth of mussels about Farm pond, show an unusual degree of impurity there.

Q. What was this deposit that you found in the bottom of your tank?

A. Well, it resembled, as nearly as possible, the material which I have in my bag here (showing it). These are some specimens I obtained from Farm pond when it was drawn down. They have been transferred from the original bottles, and have lost their original odor. I exhibited them to the Suffolk Medical Society, and all the gentlemen present will testify to their bad smell. This is material I took from the bed of Farm pond about three inches below the surface, which was the natural bed of the pond, but was overlaid in that particular locality by material having a certain amount of organic matter in it. These specimens contain roots, blades of grass, and other organic matter. They were taken from a little trench made to drain the new canal around Farm pond. From the presence of roots, grass, etc., I infer that it was a recent deposit. If it had been mud which had laid there for ages, we would not have found material of that character in it.

Mr. GREENOUGH. — You do not find the same material in the tanks in the city?

Dr. BARNES. — I found the same material under the microscope, but the particles were finer divided.

Dr. BLAKE. — Your chief objection to the water is its disagreeable taste, sight, and smell?

Dr. BARNES. — Yes, sir. The three senses condemn it.

Q. But it is not necessarily dangerous to health?

A. I should not pretend to give an opinion upon that matter. I only feel that those elements have no business in our water supply.

Mr. GREENOUGH.—Have you looked over the whole supply of Basins Nos. 2 and 3?

A. I am tolerably familiar with them; not so familiar with No. 2 as with Farm pond, and Basins No. 1 and No. 3.

Q. There is considerable discoloring matter that comes into them from the river?

A. Yes, sir; in all brooks there is considerable discoloring matter, particularly at high water. But it seems to me, if those basins were used as settling-basins instead of basins constantly taking up material, we would not have so much trouble in the city.

Q. Have you noticed any difference in the water in the basins?

A. I cannot say in regard to the color of Basin No. 2; but I am familiar with Basins 1, 3, and Farm pond.

Q. In your judgment, is the water darker after leaving Farm pond than when it comes in from Sudbury river?

A. No, sir; I only say the water of Sudbury river is naturally much darker than that of Farm pond and Stony brook, and at the present time the water of Farm pond resembles that of Basin No. 3.

Q. Now, it does not conform to my recollection of Farm pond that the bottom was covered with mud when it was drawn down last year.

A. Well, sir, on the side next to the Old Colony Railroad, where the shores are steeper, the material had not settled much, although there was some organic material mixed with the sand. But the canal cut through this deposit of mud all the way to the lower gate-house. About the lower gate-house there was a natural deposit of a very different character. The little ditches, dug to drain the canal, cut through this fresh mud from eight to ten inches; and over the entire surface there was a half to one or two inches of this material. That bottle, which is the third in size, contains but very little organic matter compared with the others. It is chiefly mixed with sand. That was taken from near the canal, on the opposite side from the Albany Railroad, near the upper gate-house. Near the Albany Railroad there was an old peat-bog which was covered with water.

Mr. GREENOUGH.—As you go along from the Albany Railroad up towards the other gate-house, where the bed was all laid bare, from the impression left upon me by the appearance of the bottom, it was all sand.

A. Well, sir, that was all cut up by men walking over it, and in digging the canal they spread the fresh sand many yards on either side, so that the condition I describe you would not find without looking for it, except as to the little ditches running towards the centre of the lake.

Q. There could not be a great quantity of deposit upon it,—such a deposit as that, for instance?

A. It was partially damp, and was trodden into the sand by several hundred men walking over it, which made a great deal of difference in its appearance; but there were places where they had not chanced to walk. I found this material ten inches under the surface. How could it be otherwise when such quantities of material have been washed from Basin No. 3, as you must have observed? Has it all gone to the bottom of Basin No. 3? No, sir; we find this loam on the bed of Farm pond and in our tanks in Boston. Farm pond is not capable of acting as a settling-basin for all the material.

Q. I should have thought there would be more from the appearance of the sand; there did not seem to me to be any large quantity deposited there.

A. I measured it with a rule. I could take up crusts, as some of it was frozen, and under it see the natural sand-bed of the pond. Farm pond must have had a hard bottom naturally, otherwise the *spongilla* could not have grown there; and yet Mr. Cutter has stated, time and again, that Farm pond had naturally a very muddy bottom. The *spongilla* is not found in Basin No. 3 because it has a natural mud-bed.

Dr. BLAKE.—Do you not think the drainage of sewage into Farm pond has something to do with it?

Dr. BARNES.—Farm pond drains a very small area. I do not think the drainage into it has anything to do with the trouble.

Q. You would not have anything drained into it?

A. No, sir; but I do not think there is any cause for trouble there of this character.

Q. Your idea is, then, that the new basins were called upon too soon, before the Water Board intended they should be, and that it carries away a great deal of this organic matter, in solution?

A. That is one of the errors, I think, among others.

Q. That is one of the principal ones?

A. It is one of the principal ones, I think.

Q. But you think it is used as a settling-basin, when it should not be?

A. No, sir; all the basins should act as settling-basins, and not throw the whole burden on Farm pond.

Mr. GREENOUGH.—You remember the taste we had last year was due to Farm pond solely?

Dr. BARNES.—Yes, sir.

Q. And digging the canal around it stopped that trouble?

A. Yes, sir; but, as Mr. Remsen said, Basin No. 3 smelt of the pigpen, and ought not to be used. It seems to me that, knowing this, the Water Board neglected its duty in not pushing the investigation further, and finding out if this was not the reason why *spongilla* grew so abundantly in Farm pond, as Mr. Remsen hinted.

Q. Then you think the *spongilla* was the immediate cause? It has been found that the *algæ* are generated from the mud-flats. What you want the City of Boston to do is to take Basin No. 3 and fix it, and then you believe the trouble will come to an end?

A. I think it will take away the nourishment for the *spongilla*.

Dr. BLAKE.—You are not referring to specific cases, but to the general character of the water?

Dr. BARNES.—Yes, sir.

Q. We are now having a particular smell. Twenty years ago we had a smell compared to that of sardines. We have had trouble time and time again in regard to the water supply. We had it just as frequently as when we had Lake Cochituate alone for our supply. When we took Sudbury river we understood we were taking a highly-colored water, disagreeable perhaps, to look at, but not necessarily dangerous to health. Now, we have that water; but superadded to it we have what has rendered it disagreeable to taste, sight, and smell, and that water holding this organic matter in solution,—is not that it?

A. Yes, sir; that is it.

Q. And you have no particular reference to the *spongilla*, or any other impurities?

A. No, sir. I cannot add anything to the valuable report of Prof. Remsen, on this particular subject. It is only that somebody neglected to go far enough to show why that trouble should exist in Farm pond. I made a rough view of that section of Basin No. 3 as I knew it in the summer of 1881 (showing the sketch). Where the banks are steep the vegetable mould has entirely washed away; the water was drawn down to this line, as near as I could estimate it relatively, and the sods were lodged along on the flats, as indicated, partially disintegrated; you could see the waves taking those particles and carrying them away. Now, it does not seem possible for it to be otherwise than that much should be deposited in Farm pond.

Q. You speak of having been familiar with Farm pond in your youth. Do I understand that at one time the banks were largely of the same character as those of Basin No. 3 now?

A. No, sir, not within the memory of man. It is a natural pond, with clean banks, or was so until the water of Basin No. 3 was let into it.

Q. Is it a fact that natural ponds always remain pure, particularly when the supply is low? Do not the water-plants have some influence when decaying in the water?

A. I think they have some influence; but I do not think we should have occasion to complain of the city water if the banks were clean. I know a little pond in my native town where I could see the bottom in many parts. Three years ago I found *algæ* there, and tried to know why they had appeared. As the result of my inquiry I found that on one side the wood had been cut off and brush dumped into the water, and I attributed the growth of the *algæ* to the decay of that material.

Mr. SHEPARD.—Have you ever known *algæ* to appear in springs?

Dr. BARNES.—I understand they have, but I cannot say so from my own knowledge.

Q. What would you attribute them to there?

A. I think the decay of leaves might be a cause.

Mr. GREENOUGH.—Do you not think the *algæ* would appear in any stagnant water?

A. Not to such an extent as to make it so disgusting as our supply is.

Dr. BLAKE.—Then your remedy is to waste the water in Basin No. 3 and clean out the basin?

Dr. BARNES.—Yes, sir; but I would not waste the water. It was emptied last summer. One objection is, that the City of Boston has no right to go on there and clean it out. But it seems strange to me that the city cannot buy a right of way to go on there. It was estimated that it would cost \$2,000,000 to concrete the bottom. That is entirely unnecessary. I never heard of such a thing as concreting the bottom of storage-basins, except from Mr. Cutter.

Dr. BLAKE.—Mr. Bradlee, is it not a fact that the basin named after you had been a source of trouble, notwithstanding all the care and preparation in the bottom and sides, laying in solid masonry to the crown-point?

Mr. BRADLEE.—Yes, sir.

Dr. BARNES.—That is because it is supplied from other sources. It is not fair to attribute it to that basin.

Dr. BLAKE.—I should like to ask the member of the Water Board a question. I want to know, Mr. Cutter, to what extent Basin No. 3 was prepared; how much work was done in excavating the bottom and preparing the sides, and what is the average depth of the soil and sides? Or, perhaps, the Engineer can answer that question better.

Mr. CUTTER.—I think the Engineer can answer it better.

Dr. BLAKE.—Mr. Wightman, will you take the floor?

City Engineer WIGHTMAN.—I did not appear here as a witness, but simply as a listener.

Statement of H. M. WIGHTMAN, City Engineer.

Dr. BLAKE.—Mr. Wightman, I want to know how much work was done under your supervision in preparing Basin No. 3, and removing loam and decayed wood, trees, and bushes, etc.

Mr. WIGHTMAN.—At that time I did not have charge of that work except incidentally, being the Assistant Engineer. But the shores of the pond were stripped to the water-line, and some distance below it. The trees were cut off from the bottom, and the bottom was practically left as any other flooded country would be. That has been the usual way of preparing those basins, except distributing basins, which are usually cleaned out and walled up with stone. For instance, Chestnut-Hill Reservoir cost, with the drive-way, \$1,640,000. Those two basins are about $12\frac{1}{2}$ acres only,—I don't remember the exact number of acres. But if you did the same amount of work in the preparation of these basins, you can see that a million dollars would be a pretty small amount, and in preparing that kind of a basin it has not been customary to spend that amount of money on it. Of course there is a certain amount of vegetation in the bottom of reservoirs, which must, to a certain extent, decay, and a basin should not be used for two or three years after it is filled. But it is not considered among engineers that the advantage of increased purity of water to be derived from the taking out of the bottoms of reservoirs

is sufficient. The vegetation in the bottom was burned before the basin was flooded. All the vegetation was got into piles and burned, and after that it was flooded. That is all that was done to it.

Q. What was done in addition to that in Basin No. 2?

A. Nothing; just the same thing there.

Q. So the basins are substantially the same, and the land was substantially the same in character?

A. Yes, sir.

Q. It had been used for farming and agricultural purposes?

A. Yes, sir. In Basin No. 3 the mud-line was six to eight feet deep, and in Basin 2 it was eight to ten feet deep. I have plans in my office showing the character of the soil. We contemplate moving a part of the loam for the Park Commissioners for the new park.

Dr. BARNES. — Is not the new basin, No. 4, being cleaned of the vegetable matter?

Mr. WIGHTMAN. — Yes, sir, the surface of it is being cleaned.

Q. Then why is it necessary to clean that, it being a storage-basin, when you do not think it necessary to clean Basin 3?

A. I believe I did not give an opinion about the necessity for it.

Q. Somebody deems it necessary?

A. The Park Commissioners want about 100,000 loads of loam, and we are taking it out.

Mr. GREENOUGH. — I can tell you about that. Somebody got up in the Council — I believe it was Mr. Whitmore, of Ward 12 — and wanted to know what it would cost to take the loam off, and was told it would cost about \$40,000; and Mr. Whitmore said he would like to have the amount put in for that purpose; and it was put in.

Mr. BARNES. — I should like to know why its estimated cost is only \$40,000 when it is estimated that a million dollars will go but a little way in cleaning other basins.

Mr. GREENOUGH. — It was put in by the City Council; but it did not come in recommended by the Water Board or the City Engineer.

Mr. WIGHTMAN. — I made an estimate of the amount of loam we could take out of Basin No. 4 which would be necessary for park purposes. I made that statement when the estimate was made, and I calculated that the Park Commissioners would pay for it. Of course, as the City Council made this appropriation of \$40,000, so far as that amount goes it will be used, and the rest will be paid by the Park Commissioners.

Q. All you are talking about is the surface?

A. Yes, sir. If we should take out all the loam, allowing that we took out 500,000 yards, at the very smallest sum, fifty to seventy-five cents per yard, it would cost \$250,000.

Dr. BLAKE. — Has it no value as a fertilizer?

Mr. WIGHTMAN. — None at all. It would cost \$250,000 to take it out, and the whole cost of the basin is \$394,000, I think.

Q. Is the average depth of the water in Basin No. 3 less than in any other basin?

A. No, sir; it is more. It is the deepest basin we have.

Q. Was it drawn upon more than any other basin during the past summer?

A. No, we always draw from Basin No. 2, because it is on the main river, and because it fills the quickest. We have been drawing from Basin No. 3, I should think, about two months and more.

Q. Had you the same amount of margin exposed in Basin No. 2 as in Basin No 3?

A. The whole bottom of Basin No. 2 was practically empty, you know. I believe I have seen Mr. Nevins' teams taking mud from the bottom. I suppose he thought it was some value to him. I noticed that the bottom was practically dry. I guess I have seen twenty or thirty teams there.

Dr. BARNES.— Were there any mud flats to be exposed in drawing from Basin No. 2?

Mr. WIGHTMAN.— If you draw it down it is all mud flats.

Q. If you draw five or six feet, would there be any?

A. I do not know. I could not tell you without looking at the plan.

Q. Then, if you draw down Basin No. 3, what would be the effect?

A. I do not think we would draw down more flats than in Basin No. 2, in proportion to the area of the basin. The area of Basin No. 2 is considerably less than in Basin No. 3. Basins No. 2 and 1 contain more shallow flowage than any other basins. In proportion to their areas they have the largest shallow flowage.

Q. Are not the banks of Basin No. 2 steeper than those of Basin No. 3?

A. I do not think the average to be.

Dr. BLAKE.— Dr. Barnes, are you pretty familiar with that country?

Dr. BARNES.— I have lived there, and know something about it.

Q. Were you familiar with the site of Basin No. 3 before it was used for storage purposes?

A. Yes, sir.

Q. Did it differ materially from Basin No. 2?

A. Yes, sir.

Q. In what respects?

A. In the steepness of its banks and shallow flowage, particularly north of the Old Colony Railroad. On the side of the railroad the water is much deeper, and that is the reason Mr. Wightman is able to make such a statement about the average as compared with the others. On the north side of the railroad there are those mud flats, which have emitted such offensive odors,— not so bad, perhaps, this summer; for it has been treated differently than in the summer of 1881, when, on account of the limited amount of water flowing in Stony brook, it was laid bare early in the season. At that time the citizens of Framingham complained of the bad odors, which Mr. Remsen said was the smell of the pigpen.

Q. Have you any experience as to the methods of purification of water? Do you believe in any of the systems of filtering?

A. Well, sir, I observed something at Basin No. 3 which might

possibly be utilized; I speak of it only as a suggestion. The dam of Basin No. 3 is laid on a quicksand; and, in consequence of that, there is a leak, which I have seen estimated at half a million gallons a day. The water coming from the basin under the dam is perfectly clear, and the man at the gate-house said it was always good in taste. While on the other side, in the basin, the water was perfectly filthy, and had these offensive smells coming up through the gate-house. It is a question whether that quicksand is not acting satisfactorily as a filter. The water had not the color, smell, and taste which the disgusting water on the other side had.

There is one matter I have omitted. I have looked in vain for the report of the Water Board, which ought to have been presented last May, that I might know what disposition was made of the water of Farm pond, when Mr. Remson recommended it should be wasted; and, if it be proper, I should like to ask the members of the Water Board that question.

Mr. CUTTER.—The water was drawn into Chestnut-Hill Reservoir so far as it would hold it, and the rest was wasted in the waste-weirs on the conduit.

Dr. BARNES.—How many of these waste places were open?

Mr. CUTTER.—I do not know as I can say. Perhaps Mr. Wightman can tell you that. The Water Board authorized the Engineer to draw the water down and construct that canal.

Dr. BARNES.—I ask this question in order that we may have some official utterance as to what became of it. You know the citizens of Boston were informed that the water was stored in Chestnut-Hill Reservoir, and purified there. There is another report that it was wasted in another direction, and, in consequence of the possible complaint of a certain city, the Water Board kept this matter a secret. I visited Farm pond several times while it was being drawn off. Dug meadow (a part of Lake Cochituate) was entirely empty when they began to draw down Farm pond. During the two weeks required to draw it off this meadow was entirely filled, and there was no material amount of rain to fill it. Mr. Lewis and myself were entirely of the conviction that the water of Farm pond was filling the meadow, and had conversation to this effect at the time. But not being satisfied with that evidence I walked over the conduit (from South Framingham to Natick), and came across a farmer, who stated, in the presence of a witness, that the gates were open on the new conduit, and the water of Farm pond went into Lake Cochituate, and was mixed with that water.

Mr. CUTTER.—I do not think the Water Board would take that water and turn it into Lake Cochituate. Not one particle of it went into it.

Q. Then tell me how Dug meadow was filled to overflowing within those two weeks?

A. We have a horse-shoe dam there, and we keep the water flowing over it.

Q. There was not any amount of water in this basin previous to the drawing down of Farm pond?

A. I was there at the time, and I can tell you that none of the Farm-pond water went into Lake Cochituate.

Q. Can you tell me what became of the waste water of Farm pond?

A. I cannot tell you that.

Q. I can produce a witness,— Mr. Lewis,— who is willing to testify to you that this meadow was filled in two weeks. Besides there is another man who said he saw the gates open, and saw the water running there. It seems to me it is an important matter for the Commission to inquire into. Mr. Lewis has authorized me to use his name

A. What Mr. Lewis is this?

Q. I do not know his first name. I will give it to the Commission, and I will give them the name of the farmer. This farmer made the statement in the presence of a reporter of one of the Boston newspapers. Several other gentlemen on the Albany Railroad observed this same thing; but I cannot point them out to you, or get them to come here.

Dr. BLAKE.— Have you any remedy to suggest? Here we have a water supply, with a rapidly growing demand, having sources of pollution. The demand is for an increased supply. Have you any suggestions?

Dr. BARNES.— Yes, sir; there have been opportunities offered to do a considerable amount of work on Basins Nos. 2 and 3, cleaning out the shallow portions of those flats which smell so badly in hot weather. It seems to me there have been good opportunities for inexpensive work, and that much could be accomplished in correcting our difficulties.

Q. That is, on the general subject of the unpleasant character of the water? For special unpleasantness we shall have to seek for special remedies.

A. Yes, sir; I think the drainage of Natick into Pegan meadow must operate as an objectionable feature, although Mr. Remsen found the water in the main lake in good enough condition. Prof. Edes, of New Jersey, who examined the supply pretty patiently one year ago, said he should consider it a misfortune for all the blame to be laid to the *spongilla*, as he found it abounding in organic matter seventy per cent. above the limit of health.

Q. I guess his estimate was a little wild.

A. No, sir; from Mr. Remsen's estimate of the organic matter in some of this water I do not think his estimate was wild. I believe that 0.15 parts of albuminoid ammonia per million should condemn a water absolutely, and Mr. Remsen's analysis showed that Farm pond had 0.404; Basin No. 2, 0.29; Basin No. 1, 0.34; Basin No. 3, 0.54; Pegan meadows, 0.63.

Mr. GREENOUGH.— Mr. Wightman, I suppose you are more familiar with the running off of that water than the Water Board are?

Mr. WIGHTMAN.— I suppose I am. It was drawn off under my direction. The Chestnut-Hill Reservoir was filled with it, and not one drop went into Lake Cochituate, nor was the waste-gate open at any time.

Q. What was this meadow?

A. I do not know what he means by this meadow. In the part

between the central turnpike and what is called Spear street, some three years ago, we put in a dam so as to keep those meadows flooded, and at the same time we put in that dam at the Natick meadows at the mouth of Pegan brook, and from that day to this the water has never been drawn off from those meadows. Even when we were short of water, when we were trying so hard to give the citizens of Boston pure water, during the period of bad water, I asked Mr. Remsen if he thought it would be safe to let that water on; and he said I had better keep it out. There never has been a drop of that water run in there, except simply what was kept there by the dam.

Q. It was not?

Mr. WIGHTMAN. — I know it did not. In spite of the testimony of the farmer and anybody else that saw it, — and I do not take the intelligent farmer's testimony, — I do not think anybody saw it.

Dr. BLAKE. — Can you give me an estimate of the number of gallons of sewage that run into Pegan brook daily?

A. No, sir, I could not. Of course there is only a small portion of the town of Natick that drains into it; but just what the proportion is I cannot tell you.

Q. It must be many thousand gallons?

A. Not so many thousand. The brook always carries much water. Sometimes after a rainfall it would run a million to a million and a half gallons a day. But in a low rainfall there is comparatively nothing runs into it, and in such times there would perhaps two-thirds or half of what was running be sewage. I do not think it could be a hundred thousand gallons a day. It may be anywhere from one to three hundred thousand gallons a day of contaminated water, and the probabilities are that not over half of the hundred and fifty thousand gallons a day would be sewage.

Q. But you think 150,000 gallons of sewage run from Pegan brook into Lake Cochituate daily?

A. I should not want to say that.

Q. That is what you said.

A. I said perhaps it might.

Q. I suppose there was a million gallons a day the day we were there.

A. I said the day you were there it might be half a million to three-quarters of a million gallons running into the brook that day. You saw that the water was quite highly colored.

Q. Yes, and annoyingly offensive. It is a smell that is in harmony with the contents of the brook.

A. I should not want to give you an opinion without looking up the facts. They are out of my mind, and this is making a rather random statement.

Q. I am more concerned about the healthfulness of this water supply. I cannot see how any authority will submit to the drainage of the towns Natick, Framingham, and Westboro' into its water supply. There are three sources of pollution which are dangerous to health. Although Prof. Remsen may say the water is all right in the city, it is not by any means conclusive that it is free from danger. I think that, under certain circumstances and in certain

seasons, it is inevitable. But we are to avert the possible dangers. I want an estimate of this.

A. I shall be happy to furnish the Commission with an estimate. That matter has been looked into once, but I do not think there has been an estimate made of the quantity. The number and causes of pollution have been looked up, but nothing said about quantity.

Dr. BARNES.—Will Mr. Wightman state to the Commission what became of that water?

Mr. WIGHTMAN.—The Commissioners know what I did with the water, and I decline to state it.

Q. Then it becomes a question of veracity between Mr. Wightman and myself?

A. I do not see what that has got to do with it. That is hardly a question of veracity. It is something you do not know anything about, and I do.

Q. There are gentlemen who saw the water running in there, and I saw the meadow fill during the time Farm pond was being drawn down.

A. I should like to have you produce them, and put them under oath.

Q. I will take the oath myself.

A. I have no doubt you would.

Dr. BLAKE.—Dr. Barnes, do you know anything about the rapidity of the growth of the *spongilla*?

Dr. BARNES.—No, sir, I do not. I refer you to Prof. Hyatt.

Q. I only want to know whether, by the carrying of the germs into these meadows, it would grow sufficiently to become offensive in a year?

A. It was reported early this year that the *spongilla* had appeared at the old conduit from Lake Cochituate; and, knowing this, I attribute its presence there at that time to the carrying of the egg into the lake.

Q. What time of the year was Farm pond drawn off?

A. I think it was the last of November. I have not the exact dates.

Q. When did Prof. Remsen make his investigation?

A. About that time.

Q. During that time the *spongilla* was found in the old conduit?

A. No, sir. Prof. Remsen went home and telegraphed to Boston to waste the water of Farm pond, which I claim went into Lake Cochituate. The *spongilla* was reported to have made its appearance in Lake Cochituate in the following January.

Q. Would it be likely to grow in cold weather to the extent or amount it was found in the old conduit?

A. I cannot say as to that. I only offer that as a suggestion. The new conduit was found lined with this material last June or July, or about that time, so that about one hundred men were employed to scrape that material off, and men told me it smelt terribly.

Mr. WIGHTMAN.—There is one statement the doctor made about the taste of Lake Cochituate; long before Farm pond had been shut off, Lake Cochituate had been shut off because it had a bad taste in it, and the Water-Board records will show it.

The CHAIRMAN. — Has any other gentleman here any further information to give the Commission on this subject?

Dr. BARNES. — The parties who have the water in charge, where Farm-pond water is said to have gone, state that it is perfectly ridiculous to say it ran into that source; and that it is no such thing, for they would not dare do such a thing as that, and pollute the water of another city.

Mr. BRADLEE. — Where do you suppose it was stated to us it did go?

Dr. BARNES. — I think I know of that matter, in view of it having been told me by two or three; and if you wish to know I should prefer to state it privately, because it is a matter that perhaps ought not to go into the public prints. I presume it is the same information you have as to where it did go. I am speaking of the waste water from Farm pond.

Mr. BRADLEE. — Do the Water Board object to his stating where it went?

Mr. CUTTER. — No, sir.

Dr. BARNES. — Well, it was stated to me by two parties in the City Government that it was wasted chiefly into Charles river; and it was kept secret at the time on account of the city of Newton taking its supply below the point of waste. They were afraid the citizens of Newton would complain of it. Now, from the engineer of Newton I hear that it is perfectly ridiculous to state that it went there. I wanted to get from the Water Board where it did go; but not having an official report from them it seemed proper to make the inquiry here.

Mr. SHEPARD. — What is the name of the engineer of the city of Newton?

Dr. BARNES. — I do not know. I will get you his name.

Mr. GREENOUGH. — What connection has that with this matter?

Dr. BARNES. — The only connection it has is to ascertain whether the City Government have been deceived about that matter.

Dr. BLAKE. — Were you aware that Lake Cochituate was shut off for two or three months?

Dr. BARNES. — I was aware of it, but I do not think it has anything to do with the subject. The Water Board made a statement that they found *spongilla* in the lake, and were going to shut it off about the first of January last.

Mr. GREENOUGH. — The *spongilla* had been there before this water was shut off?

Dr. BARNES. — But you used it from November to January, and up to that time it was good, as Mr. Remsen's report shows.

Q. But before that it had been shut off on account of the fishy taste?

A. What I claim is, that between the time Farm pond was drawn off and January the water in Lake Cochituate was used, and at that time the egg of the *spongilla* was being carried from Farm pond to the old conduit. Mr. Cutter's statement that it has not been shut off for five months is not relative to the matter at all.

The CHAIRMAN. — Is there any other testimony you would like to bring before the Commission?

Dr. BARNES.—No, sir. If you think it desirable to go into those matters I can give you the names of those gentlemen. I think there is no positive evidence of the Natick sewage vitiating the main part of Lake Cochituate, although I object to it as much as any man.

Mr. SHEPARD.—I should think the doctor could give us the names of the parties.

Dr. BARNES.—I will send you the names of the farmer and the representative of the newspaper. There is also Mr. Lewis. I am willing to swear the bottom of Dug meadow was laid bare previous to the emptying of Farm pond.

Mr. CUTTER.—You say the germ of the *spongilla* in the old conduit was produced by letting the Farm-pond water into Lake Cochituate?

Dr. BARNES.—No, sir; I say it is a suggestion worth inquiring into by the Commission.

Q. I should like to ask you how long it takes the *spongilla* to grow. The facts of the case are that the *spongilla* has been growing in the old conduit for many years, and we did not know what it was until Prof. Remsen told us. Then we shut off the old conduit and cleaned out this *spongilla* and found nearly a bushel-basketful for every square yard.

A. I think that before you were a member of the Water Board the *spongilla* had been found in the water.

Q. I beg pardon; we have cleaned out the conduit every year, but during the construction of the new supply the old conduit was not cleaned out, on account of the pressure upon it.

A. I know Mr. Wiggin reported, in 1872 or '73, that the wall of the old conduit was lined with a substance resembling sponge. Of course you know better than I do about how many times we have had trouble, and about how often it has appeared there.

Adjourned to Monday next, 9th inst., at 10 A.M.

SECOND HEARING.

MONDAY, Oct. 9, 1882.

The Commission met at 10 A.M. All present except Mr. Greenough.

Dr. BARNES.—Before the hearing begins I should like to correct a little of my testimony at the previous meeting as to the engineer's statement at Newton. I was misinformed by a second party—the engineer. Instead of saying, as I testified, that it was impossible for the Boston water to go into Charles river, he said it was impossible to vitiate the water by so doing, in consequence of a large embankment separating the river from the basin, and he might not have known of it if the water had gone that way.

In relation to the testimony of Mr. Reed, he made a statement to me about a year ago, and it was not the water-tank that was plugged, but his main supply-pipe; and he found it filled with a sediment caught by a filter, and was obliged to take the filter off.

I have asked some gentlemen to come here this morning, and quite a number said they would be present. Mr. Lewis, to whom I referred at a previous meeting, has made his appearance, and I should like to ask him to give such evidence before your Commission as he may be possessed of.

City Engineer WIGHTMAN. — Before this hearing goes on I wish to make one correction. I told the Commission the basins were stripped around the edges. I was not in charge of the work at the time it was done. Mr. Davis had charge of it. They did strip a piece of it, as I said, but after that the edges were not stripped. I wish to make a correction of that statement. They were none of them stripped except Basin No. 1. That was more or less taken off by parties who wanted the loam; but there was no systematic stripping of the pond as the work was originally laid out to be done.

Dr. BLAKE. — Why was that omitted?

A. I cannot give you the information. Probably the reason was that they needed the water so badly they could not stop to do the work.

Q. Could it be done now?

A. Yes, sir; whenever the basins are drawn down. But nature has done that.

STATEMENT OF WILLIAM G. LEWIS.

Dr. BARNES. — You reside in Framingham?

Mr. LEWIS. — Yes, sir.

Q. How long have you resided there?

A. Thirty-two years.

Q. Familiar with the water works about there?

A. Yes, sir.

Q. Ride over the Albany Railroad?

A. Yes, sir; every day.

Q. Were you riding about there during the period of the drawing off of Farm pond last year?

A. Yes, sir.

Q. Were you familiar with the condition of Dug meadow previous to the drawing off of the pond?

A. I was.

Q. What was the condition of the basin?

A. The water from Farm pond run through the conduit in the edge of Sherburne, down into Lake Cochituate, through Dug meadow.

Q. Do you remember a conversation with me at that time?

A. I do, sir.

Q. Do you remember as to our observing what the condition of Farm pond was before the water began to be used by the city?

A. It was good water, — better than Lake Cochituate, I thought.

Q. Was there much water in Dug meadow before the water began to run there?

A. There was not much water in Dug meadow previous to drawing off Farm pond.

Q. During the period that it required to draw off the pond (about two weeks) did it fill and overflow the horse-shoe dam?

A. Yes, sir; it filled from some source.

Q. Do you remember a discussion with me about that time?

A. I do.

Q. Was that practically the discussion?

A. I think I told you I had seen the flow of the water running through from the conduit from the Hayes place, through that meadow. It ran down the full stream.

Mr. BRADLEE. — Could you give the dates?

A. No; I could not, sir. I only know it was at the time Farm pond was being emptied.

Q. What means have you of fixing the date?

A. None whatever; only the time it was drawn for the purpose of carrying the spongy water and filth out of the pond, as I understood afterwards. They dug a ditch on the west side of Farm pond, and let the water run down that way after they emptied it. I think it was last year. Time passes so quickly; but I am sure it was.

Q. But you have no means of fixing the exact date?

A. No, sir.

Q. Are you certain it was filled during the period of drawing off Farm pond?

A. I should say certainly it was.

Dr. BARNES. — That was the time of our conversation?

A. That was the time my attention was directed to it. We had some conversation, and I told you what was the status of the case. I saw the water running in there, and the pond being filled up.

Q. Do you know anything about the condition of Basin No. 3 for the past two years?

A. I do, sir.

Q. Has it been offensive?

A. It has been very filthy and offensive all the hot weather.

Q. Do your cows pasture in the vicinity of it?

A. They do.

Q. Do they drink the water?

A. Where they have immediate access is in Basin No. 1; but the other basin, No. 3, is just above there. The stench comes down just below my house.

Q. Have there been complaints in Framingham about the stench?

A. Yes, sir; so much so we drove around to avoid it. We went around north-westerly, and when we turned around by the turnpike we found it about the place of Ellis.

Q. Were you there at the time of the construction of Basin No. 3?

A. I was.

Q. How much work was done upon the banks by way of cleaning them?

A. The south-easterly part, where the gate-house is, and from the Boston and Worcester turnpike, extending southerly around to Mr. Homer's place, some of the material was taken away; but on the northern and north-western side none of it was touched at all. The same surface is there now that was then, to all intents and purposes.

Q. Is there anything there now?

A. There is filth there now where the basin is not filled up.

Q. Is it offensive to the smell, or has it been during the past season?

A. It has; very much so.

Dr. BARNES. — I think that is all I wish to ask Mr. Lewis. I had intended to question him further in regard to the stripping of those basins; but, as Mr. Wightman has withdrawn his first statement, that is not necessary.

Dr. BLAKE. — You are quite positive the water from Farm pond went into Dug meadow?

Mr. LEWIS. — Yes, sir; I know it.

Q. How do you know it?

A. I was interested, but not pecuniarily, in the progress of a suit against the city by the Hayes place, and I passed by there and saw it, and absolutely saw the water running in there,— a very large stream. The time I saw it I think was Sunday.

Q. That was the only one time?

A. I cannot fix the time.

Mr. BRADLEE. — Do you know where the connection between Sudbury river and Farm pond is?

A. Yes, sir.

Q. Can you tell us where it is?

A. If the man's name is Hayes, in Sherburne, the conduit passes through his place, and just before you pass his place south-westerly on the conduit is a structure. I think it is the gate-house, or vent, or something or another,— a small thing. It is beyond the Women's Prison, just before you turn off the road.

Q. That conduit to Dug meadow?

A. Yes, sir; it runs through there. Dug meadow and Cochituate are virtually one thing. If the water goes from Dug meadow first it goes to Cochituate; but it doesn't run from Cochituate to Dug pond, because that is practically higher.

Mr. BRADLEE. — Mr. Wightman, has the entrance to the lake been altered since I was on the Board?

Mr. WIGHTMAN. — No, sir.

Mr. BRADLEE. — I wish you would state to my associates here the connection.

Mr. WIGHTMAN. — There is no connection between Sudbury river and Dug pond.

Mr. LEWIS. — I don't say there was. Farm pond entered the new conduit, and the conduit entered into Lake Cochituate by this Mr. Hayes' place. Sudbury river was never turned in there.

Mr. BRADLEE. — That is the question I asked you.

Mr. LEWIS. — Then I misunderstood you. It isn't within a mile of Sudbury river, the nearest point.

Dr. BARNES. — Here is a little diagram. Perhaps Mr. Lewis can explain the situation.

[Dr. Barnes explained the diagram.]

Dr. BLAKE. — Are we to understand it was a conversation after the water had run a certain point and had overflowed its limits there?

Mr. LEWIS. — No, sir; it was the conduit being emptied there in that way. I don't know how long a time it was running there.

[Mr. Lewis took a map of the locality, and explained the location of the several points referred to.]

Dr. BLAKE. — It wasn't running through any prepared channel?

Mr. LEWIS. — Yes, sir; there is a regular channel, — a prepared canal.

Dr. BARNES. — That channel was dug to keep Lake Cochituate full, and was used as a means of keeping Lake Cochituate full, before the new basins were furnished.

Dr. BLAKE. — The water runs from here into Dug meadow, and mixes with the water of Lake Cochituate?

Mr. LEWIS. — Yes, sir; and I saw that canal full.

Dr. BARNES. — Mr. Edwards heard something of the statements made to me by Mr. Haynes, in reference to the water running into that channel. I asked him to come in here and state what he heard, if he will please do so.

STATEMENT OF E. E. EDWARDS.

Mr. EDWARDS. — We followed the course of the new conduit from Framingham; and when we came to the gate-house, near the Hayes place, we saw there was a possible connection with the stream that ran at right angles with the conduit. We made inquiries of this Mr. Hayes, and he said that in former times the water did flow through his land, and sometimes overflowed it largely. He also spoke at this time of the draining of Farm pond, when the water went through in larger volume than previously; and it was his belief that the water was drained into Dug meadow.

Dr. BLAKE. — Did you take pains to verify his statement? Do you know it to be true?

Mr. EDWARDS. — No; I don't know anything about it. I only know, from the way it was situated, that there was a stream running at right angles in the direction of Dug meadow.

Q. Do you know that the water of Farm pond was running into Dug meadow?

A. I know nothing about it whatever.

Q. Then what did you come here for?

A. I came here to report this hearing for the *Transcript*.

Dr. BARNES. — But I wished to have him state the conversation with Mr. Hayes.

Dr. BLAKE. — I supposed you wanted him to testify to a fact.

Mr. EDWARDS. — I don't know anything about it.

STATEMENT OF HOWARD MARSTON.

Dr. BARNES. — Mr. Marston, are you buying spring water?

Mr. MARSTON. — Yes, sir.

Q. Have you been buying it for any period of time?

A. Since the 20th day of last June.

Q. Why have you been buying it?

A. Because there is so much complaint about the other drinking-water — the Cochituate.

Dr. BLAKE. — Is there very much complaint when you use ice in pretty good quantity?

A. Yes, sir; I think as much from the color, perhaps, as the taste.

Q. Well, isn't the color pretty well diluted in using the ice copiously in the water? Take melted ice, — Cochituate cannot color that?

A. It does color it very perceptibly. There is a difference in the color.

Q. Any of your customers complained of being made sick by the water?

A. No, sir; I don't think they have.

Q. Would you be willing to state how much the purchasing of spring water has cost you in your business in addition to your regular water-tax?

A. Yes, sir.

Q. How much?

A. We use about three barrels a day, at half a dollar a barrel.

Dr. BARNES. — Mr. Lewis Coleman has sent a representative here from Lewis Coleman & Co.

STATEMENT OF B. F. HATCH.

Dr. BARNES. — Has your house been buying drinking-water?

Mr. HATCH. — Yes, sir; we have, this summer.

Q. By what process do you get the water? Describe how you get it, and where you get it.

A. Well, we had been using the Cochituate water until about the 1st of June. Last year we got through the summer with Cochituate water. We didn't buy any for use in the store. We have about fifty to sixty men in the store, who drink water, besides our customers. We have a great many customers. But individuals bought water. It was brought in jugs. But this year the water was so bad we concluded to buy water for the whole store. We have been buying fifteen gallons a day from the Belmont Hill Company at three cents a gallon at Everett. The water at our store has tasted very badly indeed. It has tasted very much as stagnant water in the country in the ponds, that you very often see, where weeds are growing. It has tasted so much so that we could not drink it, and could not offer it to our customers.

Dr. BARNES. — I have promises from other gentlemen to be present at this hearing, and Dr. Beach asked me to ask the chair-

man to have an adjournment, as he knew people who wanted to come here and testify.

The CHAIRMAN.—If Dr. Barnes will give way one moment, as this question of how the water was let out of Farm pond is before us, I would like to call on Mr. Desmond Fitzgerald.

STATEMENT OF DESMOND FITZGERALD.

The CHAIRMAN.—Mr. Fitzgerald, you have heard the statements about how the water was let off?

Mr. FITZGERALD.—Yes, sir; I have heard them.

Q. Have you the facts in the case?

A. Yes, sir. Dr. Barnes never has come to me for the facts, or I should have given them to him before. We have nothing to conceal about it. We keep very accurate memoranda of the time we open these gates, and the quantity that passes out. I suppose our records are the most complete of any system of water works in the country; and if Dr. Barnes had come to us for them he could have ascertained where the water ran, and where it came from. We began to run water from Farm pond on Nov. 15, 1881, at one o'clock in the morning, and we ran it until December 2, when the water was shut off. Not a drop of that water which came from Farm pond was run into Cochituate in any way.

Dr. BARNES.—Was it run into Dug meadow?

A. No, sir; not a drop of it run in there. I can give you the exact quantity,—a hundred and ninety-one million four hundred thousand gallons. We didn't open the gates; the man in charge of the gates I always give instructions, as soon as he opens the gates, to keep an exact memorandum of the time he opens the gate, and the time he keeps it open; and here I have the original memorandum. Besides, we have our official records showing the exact amount of water that ran out, and what was done with it. Not a gallon of that water was wasted from Farm pond into Lake Cochituate.

Q. Was it wasted into the basin connecting with Lake Cochituate?

A. No, sir; I am not trying to dodge the question.

Dr. BLAKE.—Did it either directly or indirectly?

A. No, sir; neither directly nor indirectly.

Q. Are there not gates to connect the new conduit with Dug meadow?

A. Why, certainly; but the gates were not open. There is a way it can go; but it wasn't run that way. Now, I think I can explain what seems to be a contradiction of testimony here. After the canal around Farm pond was completed, we ran water from Basin No. 1 around through that canal,—perfectly good water,—into Lake Cochituate, because we had a break on Basin No. 1. In order to repair it we had to draw the water from Basin No. 1. If anybody saw water running there, it was after Dec. 5, 1881.

Q. And you had finished emptying the pond on December 2?

A. Yes, sir; and at twelve o'clock, noon, the flow was stopped.

I do not think there is any intention on the part of anybody connected with the water works to conceal what we did. We never refused to give any information as to what was done with the water.

Q. Well, the trouble has been that these gentlemen who come here to testify — Dr. Barnes and Mr. Lewis — were not aware of the fact you have stated ; and they naturally supposed this water was from Farm pond.

A. But they should know the date. It was after December 5th.

Dr. BLAKE. — They didn't know about the dates.

Dr. BARNES. — I knew the dates. I knew when Farm pond was drawn off, and when it was stopped. I made a note of it, and have the notes at home in a note-book which I made at the time.

Mr. FITZGERALD. — I don't think it would be possible to find anybody to testify that the water was running out into the Sudbury aqueduct between December 5th and 15th.

Dr. BARNES. — I don't know that it is necessary for me to pursue the subject further. I am not here as a prosecuting attorney. I am only interested in getting good water for the city of Boston, and only suggested this thing for you to ferret out.

Dr. BLAKE. — I think it is for the Commission to find, when the Doctor makes a positive statement that diluted water is mixed with the water supply, whether it is true or not. Now, if the Doctor can substantiate his statement by dates, he ought to do so. This gentleman, who is in charge of the water, denies it in the most positive and emphatic manner.

Dr. BARNES. — I understand that. Mr. Wightman says the basin was kept full all the time ; and now this witness comes here and says no water had run in that direction.

Mr. WIGHTMAN. — I made no such statement that there was no water run over that dam. The statement I made was that no water from Farm pond ran over it. I said the water wasn't drawn off the meadows, and never was during all that year ; and that year —

Dr. BARNES. — I hope, gentlemen, you will ascertain from people who live in the vicinity of that meadow.

Mr. WIGHTMAN. — Mr. Fitzgerald can testify as to that.

Mr. FITZGERALD. — I will take my oath. In order to make our account come out we have to keep an exact account of every gallon of water that goes into our basins, and where it goes. We have a most accurate way of measuring that water. There were one hundred and ninety-one million four hundred thousand gallons. When we began to draw Farm pond down, on November 17th, the level of Farm pond was 145.96 above tide level. We drew it down to December 2d, but didn't lower the pond after November 30th, and the elevation was 142.17. That was the lowest Farm pond got. Not a drop of that water was in any way, shape, or manner run into Lake Cochituate.

Dr. BLAKE. — I would like to have Dr. Barnes satisfied on this subject.

Dr. BARNES. — I made a note of it at the time.

Mr. BRADLEE. — Are you sure of it?

Dr. Barnes. — Yes, sir. I am familiar with it.

Q. Is Mr. Lewis sure about it?

A. He knew, and many persons about Framingham talked about it. It was between the time they were drawing off and ended drawing off Farm pond that this basin filled, and I made a note of it, which I can find at home.

Mr. FITZGERALD. — I should like to see it.

LETTERS AND PAPERS READ.

Dr. Barnes. — I have some letters from persons unable to attend this hearing, but who wished to present testimony.

Dr. Barnes read the following: —

PARKER HOUSE, BOSTON, Oct. 9, 1882.

City of Boston: —

GENTLEMEN, — We have been buying spring water of Nathan Robbins for the last eighteen months, — from three to four barrels a day, — for the city water has been so bad our people would not drink it.

Respectfully,

H. D. PARKER & CO.

HOTEL VENDOME, BOSTON, Oct. 9, 1882.

MY DEAR DOCTOR, — As I cannot conveniently be present at the hearing at City Hall on the water question, I herewith send you a letter from the proprietor of the hotel for your use, if you desire it.

In addition, I would state that the water, as drawn from the faucet in my office, is of dirty color, offensive taste, and the odor from the hot-water pipes at times is simply disgusting.

I have long since abandoned its use in my family, and purchase spring water for drinking purposes. While I have not investigated its deleterious qualities, what I have here mentioned is sufficient cause, in my opinion, to condemn it as unfit for use.

M. E. WEBB, M.D.

DR. H. J. BARNES.

To the Commission on Water, City of Boston: —

As one of the petitioners requesting an investigation into the causes of the impurities of our water, I desire to testify that the water supplied to my residence has been for the most of the time during the past year unfit for drinking purposes, and that during the past summer I took pains to examine the water-basins in Framingham, particularly Basin No. 3, and that from the color and odor of the water stored there I was not surprised at the great complaint made by so many of the residents of the city.

I regret that my professional engagements will prevent my appearing before your body to give the testimony.

Respectfully submitted,

W. H. BAKER, M.D.

240 Commonwealth avenue.

BOSTON, Oct. 8, 1882.

H. J. Barnes, M.D.: —

MY DEAR DOCTOR, — Professional engagements will prevent my attendance at the City Hall to-morrow, at the hearing before the special Water Commission. Knowing that you are to be present, I take the liberty to send you this note, that you may make use of it, if necessary or advisable, as the expression of the opinion on the part of myself and my family that the water which has been supplied to us by the city has for a long time been totally unfit for drinking, and much of the time for toilet purposes. It may be said, perhaps,

that boiling will do away with its objectionable features. In reply to this I would state that my wife has, on several occasions, been nauseated by the stench which came from the water which had been drawn from the hot-water faucet for our infant's bath, and I would add that boiling water which emits such a foul odor as to nauseate one cannot, by any process of reasoning or analysis, be proved, to my satisfaction, to be fit for drinking or culinary purposes. Holding this view, I have for a long time felt myself obliged to assume the additional expense of purchasing spring water.

I trust that the meeting to-morrow will be attended by a large number of our citizens, who I know feel as I do in the matter, and who demand that something be done to improve the quality of our water supply, first on sanitary grounds, and, secondly, to relieve us of an unwarranted pecuniary burden.

Very truly yours,

W. E. BOARDMAN, M.D.

BOSTON, Oct. 7, 1882.

Dr. Henry J. Barnes :—

DEAR SIR,—The water at my residence (103 Charles street) has been exceedingly offensive both in taste and in smell. Although somewhat improved lately, it is not by any means what water used for drinking purposes should be.

Yours truly,

W. MACMAHON.

DR. BARNES.—I have also received a note from Gen. Underwood, of Milford. I will present it here, although it might be used more properly at another part of the discussion. (Reading) :—

MILFORD, Oct. 6, 1882.

DEAR SIR,—Having known Farm pond in Framingham for the past forty or fifty years, I will state that, to the best of my knowledge and belief, the pond was a beautiful, clear lake of water until the water of the Sudbury basin was turned into it.

Very truly yours,

O. UNDERWOOD.

DR. BARNES.—I have also a letter here from Mr. E. S. Philbrick; but, as I have not his permission to present it, I desire to see him to ask permission to present it to the Commission. It is in discussion of this subject.

I should like to read to you a leader in the *Boston Medical and Surgical Journal* of August 3, 1882:—

BAD DRINKING-WATER AND POLITICS.

Wherever stored water is exposed to such intense heat as must result in shallow reservoirs of surface water, in climates like that of most of the cities of the United States and many parts of Europe, it is liable from time to time to contain the sponge, the decay of which gives rise to the peculiar "cucumber," "oily," or "fishy" taste now and then complained of in Boston. This does not occur in the temperature of London, or in such deep, gravelly-bottomed ponds supplied by underground springs, as Lake Wenham, for instance, where the heat never rises to the height requisite for the development of that particular form of growth. Naturally, therefore, the liability to the disgusting taste and smell would be increased, as was the case by damming Lake Cochituate, and flowing many acres of meadow land. It does not appear that vegetable or animal filth increases this liability, although there are other objections to the town of Natick using Lake Cochituate as its cesspool. Professor Farlow's careful researches — which cleared the way for Professor Remsen's lucky hit in finding the real *causa causans* of this curious taste and

smell — have apparently satisfied the Water Board and many of the public, to judge from the sententious advice: "If you don't like the water, drink whiskey," and from the readiness of our citizens to accept what seems to them the inevitable, and purchase their drinking-water. It is a fact that we do not yet know how to avoid this nauseous taste; but it is also a fact that it comes only at intervals of several years, lasts only a few days, disappears upon boiling, and is probably not prejudicial to health.

The chief trouble in the Boston water supply at present was predicted by the eminent city engineer whom the politicians drove from Boston, to the great loss of that city, and had already been clearly illustrated in the flooding of the Lake Cochituate meadows years ago. It consists in the simple fact that the Sudbury-river reservoirs were built contrary to all principles of science and common-sense; that many acres of very shallow water cover turf rotting away slowly; that the conditions for the growth of low forms of aquatic life are produced; that a bottom covered with a nasty mass of filth takes the place of gravel; and, finally, that the citizens are drinking bog-water, which is sometimes pretty good, and often very bad, — just in proportion as it is mixed with greater or less proportions of decent water. It is probable, too, that these conditions of varying heat and nastiness may be something of a factor in the production of the *clathrocystis* and *cælosphaerium* and *anabæna*, which every few years rouse the wrath of the citizens, to be appeased by the Water Board's perennial habit of taking a few chemical analyses, and by the natural disappearance of the plants.

Another clear source of the dirty water observed in our bath-tubs lies in the fact that many of the water mains were laid before the practice of coating the insides with tar was in vogue, and that the roughnesses of the surfaces cause vegetable débris to collect and to be unevenly distributed.

It needs no elaborate argument from us to prove that the public health is not sufficiently attended to in that city, where only the rich can have pure water to drink, and where the temptation to the poor to drink bad rum is increased. Nor shall we endeavor to show that the public morality is low where important public trusts, such as the management of water supplies, are made subservient to politics.

Beyond this question, as applied to Boston, and partly in connection with it, comes the difficult problem of water and sewerage for the State, which can be properly treated only by general laws. Let us hope that such legislation will not be like that of the Butler-fearing Solons, who allowed the shoemakers of Natick, by special enactment, to bathe in Lake Cochituate rather than lose a few votes.

If we are to become so extravagant in the use of water as to require one hundred gallons daily to each individual, there must be either separate supplies, as in every farm-house, for drinking and for other purposes, or else water-meters must be introduced, as has already been done in other cities.

Dr. Barnes. — I will close, gentlemen, by reciting to you what are my own special views in regard to this matter, as published in the *Medical and Surgical Journal* of January 26, 1882, which is a paper I read before the Suffolk District Medical Society.

THE WATER SUPPLY OF BOSTON.

By HENRY J. BARNES, M.D.

The public supply of water for the City of Boston has so far improved that we can once more drink without disgust, although it is still highly discolored, and there is a disagreeable smell, particularly in that drawn from the hot-water faucets. The change took place during the cold weather in the early part of December; and it is reasonable to ascribe this to the weather quite as much as to the fact of Farm pond being shut off; for, just before the new channel was finished around the margin, I could not detect the bad taste so familiar in Boston in the water of this pond. Besides, we did not get the good water from Basin No. 2, as promised by the Water Board, for an accident to the main laid in the bed of Basin No. 1 necessitated the mingling

of the water of the two basins before it could be used through the new channel, and the analysis of the water of No. 1, made by Mr. Remsen November 5th, prompted him to classify it, in point of impurity, with Farm pond, Bradlee basin, Pegan meadows, and Basin No. 3. His subsequent discovery of *spongilla* in Farm pond seems to have so occupied public attention that the filthy conditions of the other basins, where no sponge has yet been found, have been lost sight of. To emphasize the importance of these other basins as factors in polluting the water, I invite your attention to this subject; and that you may be better able to follow the discussion I will describe first the relative positions of the basins of the Sudbury-river system by the aid of a diagram. This system of supply is naturally good. Sudbury river compared favorably with all the many systems examined when Boston debated in 1872 and 1873 which to adopt; and, finally, when narrowed down to a question as to whether it or the Charles river should be taken, its freedom from sewage settled the debate in its favor.

Mr. Davis, the city engineer at the time, reported, in City Document 29, page 28, 1873: "There are various reasons for believing Sudbury-river water to be unusually free from deleterious matter, either in solution or held in suspension. Such was the testimony of all persons consulted, this water being used for many years for bleaching, and noted for its fitness, indicating it was free from color," etc. Again, on page 33, Mr. Davis writes: "The usual water of Sudbury river is pure and clear." These were his conclusions, although at the time there was some discoloration, due, as he says, "to the taking up of vegetable matter during a freshet after an unusually dry summer."

Professor Reinsen's more recent examination supports this opinion so far as it goes.

Stony brook does not seem to have received so much attention, presumably for the reason that not even a suspicion of impurity has ever been raised in regard to it. A farmer living near it, just above No. 3, tells me he "has always known the water to be clear and good." I can find no authoritative statement that either receive any considerable amount of sewage, but, on the contrary, many reports that it does not exist to any appreciable extent in the water of either of those streams.

There remains the natural basin of Farm pond to describe, which, before the introduction of Sudbury-river water, was pure and clear. It received the drainage of a very limited area of the flat territory around, — not even a good-sized ditch emptied into it, — and its outflow was into the Sudbury river. The clean stone and gravel bottom could be seen from many parts of the surface. At either end there is a peat-bog of several acres, and in the deepest parts considerable mud, which the Water Board state measures thirty feet in some places; but this may be fairly questioned when we take into consideration that it is a shallow pond, situated on a plain which abounds in quicksands as easily penetrated by a pole as mud would be. I have been familiar with the pond for the past twenty years, and have always known the water to be pure and clear until the water from No. 3 was let into it, when it became dark and turbid. Mr. Davis, in City Document 29, page 26, 1873, says, that Farm pond, being a natural basin, but little work is needed to put it in good order.

The water of this supply was first used in the summer of 1872 by constructing a temporary dam on the Sudbury river, just below the outlet of the pond. At the other end a channel was dug to conduct the water into Beaver brook, a tributary of Lake Cochituate, and by these means the lake was supplied and kept full most of the time until the completion of the new conduit connecting Farm pond directly with the Chestnut-Hill reservoir, and for seven years we had no trouble with this water. The local engineer reports in City Document 79, page 128, 1879, "that the surface of Lake Cochituate has, by this means, been kept higher than usual, and the quality fully up to the standard of previous years."

The trouble with the water began after the completion of Basin No. 3. This basin was filled for the first time in the winter and spring of 1878 and 1879; the following September there was a general complaint throughout the city of bad-tasting water. *Algæ* were found in all the basins, and Mr. Davis, in one of his reports to the Water Board, said it was conveyed

from No. 3 to the others. Professor Nichols attributed it to vegetable matter taken up in the storage-basins.

Let us now examine No. 3, and notice what changes took place there. I have a sectional view of this basin as it appeared after the water was drawn down last summer.

Mr. Davis anticipated this effect; for, in Document 29, page 43, of his report in 1873, he urged the "rapid construction of the new basins, that they might have time to decompose the vegetable matter;" and on page 35 he says: "No. 3 includes an extensive swamp, and lands supporting a rich vegetation, which it is desirable to have removed by grubbing and excavation, as it will, otherwise, have to be gotten rid of by a slow process of decomposition, which will be apt, in the summer months, to deteriorate the water." One would suppose that, with this recommendation and the experience the Water Board had gained by disregarding it, they would seize the first opportunity to free the basin of this material. Not so, however; they caused it to be refilled to the line of clean gravel, and it purified itself during the winter. The next year it was drawn on, but to a limited extent. There were some *algæ*, but the water was fair during the year. Last spring, being full to the line of clean gravel, it was so good that, with water from Basin No. 2, the entire supply of the city, save that furnished by Mystic river, was taken from this source. The effect was to lower the water rapidly in No. 3, and expose vast mud-flats and banks in the early summer, which, exposed to the hot sun, became very offensive. The alternate rise and fall of the water, the waves and the currents assailing the banks, washed away great quantities of these overflowed farm-lands, which for many years had received the products of the barn-yards, and were full of dead animal and vegetable material. The earth-worms alone, Mr. Darwin tells us, number 26,000 per acre, and their excrement amounts to ten tons a year. Beetles, moles, grasshoppers, sewer-bugs, and many other forms of animal life make up material undergoing the process of decomposition. Do you wonder that these flats have been infested by large flocks of crows, here doing excellent work as scavengers?

Then, as to the decaying vegetable matter, do any of you as boys remember the opening of a vegetable cellar in spring, and its disgusting stench, or the decay of hay about the barn-yard? Is it to be wondered at that Mr. Remsen should say "the water smelt of the pigpen," and ought not to be used, or that the citizens of Framingham should complain of the smell?

Now let us trace this filthy water to Boston. It is conducted, as I have shown you, through Basin No. 1, without mingling with its waters, into Farm pond. Drawn from the lowest point of the basin, the greatest amount of suspended material is swept into the pond, there to spread over this shallow sheet of water, to steep and macerate during the summer. Much is deposited, for the current is slow; and since the pond has been drawn off I have taken pains to measure the depth of the deposit.

About the upper gate-house an inch at least overlies the clean gravel, and the new channel cuts through it all the way to the gate-house at the other end of the pond. As you approach the natural channel it is much deeper; there are three to six and even ten inches of this material, filled with sticks, roots, and blades of grass, such as you will see in one of the bottles I show, the presence of which leads me to infer that it is recent. Mr. Van Vieret found this mud to emit very offensive gases; another fact tending to show that the deposit is recent.

The *spongilla* was found by this gentleman distributed only in that part of Farm pond which Mr. Wightman, the present city engineer, pointed out at a meeting of the Natural History Society as being the natural channel between the two gate-houses, and it was found in greatest abundance about the upper gate. Professor Hyatt, at the same meeting, described the habit of the *spongilla* as attaching itself to hard surfaces and living by absorbing quantities of water, from which it selected its food. I find in Griffith and Henfrey's Micro-graphic Dictionary that *algæ* are its chief nourishment. It is not fair to infer, then, that the luxurious growth of the *spongilla* in Farm pond subsists on the organic material introduced from "pigpen," and that it is living at the expense of quite as noxious material as itself.

Farm pond is not capable of acting as a settling-basin, for all the material

from it comes into our houses in Boston to clog the filters and pollute our tanks. I found in mine a deposit of mud three-quarters of an inch deep, which a short time after being taken out became very offensive. Half a dozen or so of coagulated masses were partially suspended near the bottom, and the sides were lined with a soft, slimy-feeling substance, which, under the microscope, showed abundant *algæ*. The tank was at the top of my house, and fed by a faucet governed by a floating ball, insuring a slow current, and thus giving the most favorable chance for the material to settle in the pipes, and be drawn off through the faucets in the lower stories. It was cleaned and securely covered eight months before.

If these conditions suggest anything it is that the supply is contaminated first in the new basins by taking up decomposing animal and vegetable matter. Mr. Davis hoped that the new basins would be "completed some time before it would be necessary to use the water, that they might assume the character of natural ponds." By this process Professor Nichols recognizes the dangers of vegetable matter in storage-basins when he writes: "Deposit in storage-basins goes on continually, and is preparing evil for the future, as this deposit undergoes a slow process of decay." Instead of a slow process of decay these vast lands were uncovered early in the summer, and the most rapid process of decay and decomposition possible was the result. Professor Edes, of New Jersey, examined Boston water last summer, and states in brief "that it contains pollution amounting to seventy per cent. above the limit of health, and that he found it abounding in decomposing organic matter." Does any one but Boston's Water Board pretend that all this filth comes from the once beautiful Farm pond? No, gentlemen; it comes from the new basins, and you can see it passing, as I did December 10, when the color of the water in the new channel cut around Farm pond was that of good coffee.

In 1854 Dr. Jackson attributed the trouble in Lake Cochituate to the decay of vegetable matter. In 1873 the Water Board, having Mystic in charge, "congratulate the city on having provided additional pumping-power, and enabling them to draw off the water, giving a long-desired opportunity to clean the basin."

The Mystic basins were chiefly built like those on Sudbury river; and you know how often complaint has been made of the bad taste of the water. In dry seasons vast mud-banks here have been exposed, I am told.

Cochituate has been drawn low many times, exposing the mud, particularly in that part of the basin next to Natick, which receives the sewage of Pegan brook. It can hardly be doubted but that this has operated to vitiate the water of Lake Cochituate. Westborough, Mass., has had trouble with its system, and the engineer under whose charge the work was done, writes me that he attributes the trouble to vegetation left in the basin, the gentleman representing the town disregarding his recommendation to remove it. Newton, taking Charles-river water, excavated a basin something like one thousand feet long, from which the water is pumped, and it has always been good.

Mr. Wilde, member of the Water Board, having the care of Spot pond, tells me "the trouble was caused there three years ago by the exposure of vast mud-banks during a dry summer. The following spring the ice which had frozen to this mud raised a great quantity of it, which was distributed in the water when the ice melted." Albany, taking its supply from Lake Rensselaer, thought to increase the area by raising a dam. A bad taste of the water was the result; and Professor Chandler, considering the decaying vegetable matter to be the cause, advised its removal, which was done, and relief followed. The basins at Chestnut Hill gave us no trouble when first constructed, for the wash of the banks was guarded against by a clean stone lining. The water of one of them is said to have had a bad taste for a short time in 1875. I do not attempt to explain the trouble, but in view of its receiving water from Lake Cochituate through the old conduit which Mr. Wiggin reported, after an examination, "to be lined with a growing substance resembling sponge," and Mr. Davis subsequently reported "the sides covered with a vegetable growth," it is suggested only that the trouble might be introduced from this source. The late Dr. Jacob Bigelow said "that the water of Sudbury supply would not be good until the basins were cleaned;" and Professor Sharples, in an interview published in the *Herald*, November 21, says, "I do think

that, in every case, so far as reported, the smell and taste can be traced to decay of vegetable or animal matter."

You will naturally ask why the water of Basin No. 2 on Sudbury river should be good this fall, while Nos. 1 and 3 were bad. It differs from them in that its banks are steep and there are no extensive mud-shoals to be exposed when the water is partially drawn off. It is a small basin, supplied by the considerable amount of good water flowing in Sudbury river. The steep banks have been effectively washed down to the clean gravel, and it has been kept full except for a short time in the early part of last summer.

I do not discuss the theories advanced by able men as to the causes of trouble, for I admit that all, save "the fish story," have an abundance of evidence to support them. But I do claim that they each depend on the organic matter taken up in the basins decomposing and furnishing nourishment for the many forms of noxious life found in our water, and which imparts to its taste, smell, and color by their decomposition.

Dr. Barnes.—Dr. Beach promised to be here at 11 o'clock, if possible, and if not, would send me a note asking that there be adjournment of the Commission, that other evidence might be produced. But it seems to me, with the evidence and letters produced, you have enough to prove there is complaint. One of the principal banking men of Boston said. "D—n it! don't the Commission know that there is complaint? I think they should know it. I haven't time to go and tell them. I can afford to buy spring water."

Dr. Blake.—It seems to me, Mr. Chairman, we might admit that fact, and that there is no necessity for cumulative evidence.

The CHAIRMAN.—We will admit the fact. It is admitted that there is complaint; but the question is: What is the cause, and what is the remedy?

Dr. Barnes.—Another question in reference to the cleaning of Basin No. 3. Mr. Cutter says it will cost two millions to clean and concrete the bottom. Mr. Wightman says it will take between a million and a million and a half. I labor under a great misapprehension if the loam in Basin No. 4 is not being removed at an expense of \$40,000, and it is an immense basin. If it is going to cost only \$40,000 to clean Basin No. 4, I hope Mr. Cutter will reconcile that fact with you. I do not claim to be an engineer, and am not an expert in this matter, and only present what has occurred to me during the last two or three years in observing this subject.

The CHAIRMAN.—This appropriation was made not on any specific estimate. It was made in the Common Council without any actual estimate of the cost. That was the way the \$40,000 was put in.

Dr. Barnes.—It seems to me Mr. Greenough's connection with the water supply, being on the committee, would enable him to state somewhere near the expense of cleaning Basin No. 4. In reply to Mr. Whitmore, in the Council, he said \$40,000 would probably do it. I think Mr. Greenough is capable of estimating the difference between \$40,000 and a million and a half.

The CHAIRMAN.—I do not understand that an estimate has been made by the engineer.

Dr. Barnes.—I understand the testimony of Mr. Wightman is that it will take about a million and a half dollars;—will go but little way.

Mr. WIGHTMAN.—I should like to interrupt just here. I made

a statement that Chestnut-Hill reservoir cost \$640,000. Its banks are covered with stone paving and coping, and it has walks around it. I certainly would not be willing to make a statement that it cost a million and a half dollars to take the loam out of that basin.

Dr. BLAKE.—I don't understand that the engineer made any such statement. I understood him to say it would cost two or three hundred thousand.

Dr. BARNES.—His statement was that a million dollars would go a small way toward doing that work.

Mr. WIGHTMAN.—That is Chestnut-Hill reservoir.

Dr. BARNES.—Nobody asks for that work.

Dr. BLAKE.—But the question is the removal of the loam from Basin No. 3.

Dr. BARNES.—And Mr. Wightman brings in the question of making a grand boulevard like that about Chestnut-Hill reservoir to compare it with.

Mr. WIGHTMAN.—I made a statement that Basin No. 4 contained about a half million yards of what we call loam, and I suppose it could be taken out for fifty cents a yard. That was the only statement I made about taking out loam; and I never made such a statement about Basin No. 3. Of course Dr. Barnes can state that I said so; but the reporter has it down in black and white what I did say.

Dr. BARNES.—There is one other thing I desire to say, and that is in regard to the pollution of Bradlee basin. In view of the statement made by Mr. Cutter, of the efforts to remove the *spongilla*, it seems to me the pollution of that basin might have come from the *spongilla* in the old conduit.

Mr. CUTTER.—I should like to interrupt, and ask why the Lawrence basin was affected in the same way?

Dr. BARNES.—I have only your reports on the subject, and do not know if it is so, or not. I only know the conduit has been lined with *spongilla* from time to time, and has the same conditions for growth as in Farm pond, namely, the laying bare of those meadows, Pegan and Dug, year after year, where the *algæ* and other forms of aquatic life find nourishment, and has thus nourished the *spongilla* in the old conduit.

Gentlemen, I am very much obliged to you for your patient listening to me.

Mr. FITZGERALD.—I suppose you are aware that the *spongilla* were in Lake Cochituate before they took the water for Boston?

Dr. BARNES.—Yes, sir; I understood Dr. Jackson found it there.

Mr. FITZGERALD.—I have seen it at the upper end for the last ten or twelve years.

Dr. BARNES.—Yes, sir; and for the last ten or twelve years you have laid bare Dug meadow and Pegan meadow, and furnished it with sufficient nourishment to vitiate the Cochituate water from time to time.

Mr. CUTTER.—Dr. Barnes understood the odor in and about Basin No. 3 was so bad that people passing by shut the car-windows down; and he says that, if you call on any of the residents

about there, they will tell you it smelt like a pigpen. We have a resident here, and should like to have him make a statement.

STATEMENT OF SAMUEL B. BIRD.

The CHAIRMAN. — You reside there?

Mr. BIRD. — On the north side of Basin No. 3, Framingham.

Q. Have you seen any trouble, or any bad effect or smell, from the pond?

A. No, sir; I never noticed any bad smell from the pond since the basin was filled. My cows go to the basin every day for water, except in winter, and we have used the water from the basin in washing in the house. Of course, the water has been warm which was used in washing, and we never noticed any bad smell. When the water is very low there is a sediment in the water, and it requires to be strained before it is used in the house; but we never noticed any bad smell.

Dr. BLAKE. — Do you take the water out of Basin No. 3 directly for domestic purposes?

A. Occasionally.

Q. What is your water supply?

A. From wells; but last year and this year the water has been quite low in the wells, and we have been to the basin several times for water.

Q. You make tea and coffee of it and drink the water of Basin No. 3?

A. No, sir.

Q. Why not?

A. Because we have it in wells.

Q. But when your well is low, what do you do then?

A. The water has never been so low but we used it for cooking purposes.

Q. But you never noticed the water dipped from the margin of the pond was offensive when heated?

A. No, sir; I never noticed any bad smell from it.

Q. Has the water been lower in Basin No. 3 this year than previous years, leaving a wider and deeper margin exposed?

A. It has not been so low this year as last year, — at no time.

Q. Even when this large margin was exposed you have not perceived any offensive odor?

A. No, sir.

Q. And your sense of smell is as keen as most men's?

A. Yes, sir, I think it is. It is within thirty rods of the house.

Dr. BARNES. — Which side?

A. On the north side. The south and south-west winds are the prevailing winds during the summer.

Dr. BLAKE. — Have you noticed that the margins or edges of the pond or basin looked offensive?

A. The edges are improving every year. The soil is gradually being washed down into the low places, leaving a gravelly margin.

Q. That is a fact?

A. That is a fact.

Q. What percentage should you judge had been washed away, leaving the margin gravelly?

A. I could not give you an intelligent answer, not having been around the basin; but near my own house the border is almost all gravelly.

Dr. Barnes. — Do you know of any complaint by citizens of Framingham of the odors from those basins?

A. I haven't heard any until I heard Mr. Lewis' statement to-day. That is the first I heard of it.

Dr. Barnes. — I wish the Commission would get the opinion of those living near Dr. Johnson's place. I cannot summon witnesses to come here. I know very well there are gentlemen living there who complain of the smell from those basins.

Dr. Blake. — You are quite a prominent man in that community, Mr. Bird, — assessor and member of the school board, — and brought in contact a good deal with people who live there. Have you heard any complaint of this pond being offensive?

A. I haven't heard anything, except as I have heard it on the stand from men who have been summoned in suits against the city. I am familiar with my neighbors who live on the borders of the pond; and I know their opinion as expressed daily, as I meet them, in regard to it. Aside from witnesses summoned against the city, I haven't heard any complaint.

Q. So that disinterested parties find no cause for complaint?

A. No, sir; and I know neighbors of mine who use the water almost daily from the basin for washing purposes. The manager of the town farm has been in the habit of going to Basin No. 3 for water for washing purposes, and his cattle go there to drink. Another neighbor, who lives within ten rods of the basin, uses it and his children play in it. They think a great deal of the water, and have never complained of any offensive smell.

STATEMENT OF T. B. BRIGGS, OF CAMBRIDGE.

Mr. Briggs. — I had the honor, or dishonor, of writing an article in the *Herald* some time ago, which may undoubtedly have had something to do with this investigation and hearing. I believe the Water Board want to get at the facts in the case, and wish to know what is best to be done. They do not wish to throw away the city's money, and they are willing to use the money of the city for the benefit of the city when they are convinced it is really necessary.

In regard to cleaning the basins, or covering them with concrete, silver, gold, or glass, I don't see how it would remove the difficulty so long as the source is polluted, so long as it comes from such a place as Sudbury river, with which I am pretty well acquainted. My suggestion or inquiry is this: whether there may not be some system of filtration before the water enters the basin, or enters the pipes, on a large scale of two hundred feet long and of depth and breadth accordingly, so that the water can be thoroughly filtered before it comes into the pipes. Could we not have such a system? I think they have such a system in Connecticut, which is

a great success. I could not give the facts fully in regard to it, but I was reading of it some time ago. A very large system of filtration was entered upon and they found it was really a success. If we could have some such system as that, by which the water could be purified, it seems to me it would settle the whole thing. I think the trouble has been largely owing to our dry summers. They have had the same trouble in New York, and we are liable to have poor water at any time unless there is some way to correct this abuse. I understand that my friend, Dr. Barnes, who has testified, agrees with me that there should be some plan of filtration.

Dr. BLAKE. — Are you the author of the article, of the 18th of December, on the "Water we Drink"?

A. No, sir; that wasn't mine. Mine was concerning "Sudbury River, and What Shall we Drink?"

[Adjourned to Tuesday, Oct. 17, at 4 P.M., at which time a quorum of the Commission did not appear, on account of professional engagements of some of the members, and a further adjournment was had, subject to the call of the chairman.]

THIRD HEARING.

OCTOBER 27, 1882.

The Commission met at 4 P.M. Present: Messrs. Caldwell, Chairman; Blake, and Greenough.

Dr. BLAKE. — Dr. Barnes, Mr. Wolcott, of the Hotel Vendome, and others, which were laid on the table.

Mr. GREENOUGH. — Was there testimony at the last hearing to the effect that there never was any smell?

Dr. BLAKE. — There was testimony introduced of that character. Mr. Bird, who is pretty familiar with that locality, testified that no unpleasant odor was ever noticed by people about there who were in a position to notice it, if such existed.

Mr. GREENOUGH. — I suppose that what we want to hear to-day is a statement from the Water Board about the water supply.

The CHAIRMAN. — Is there anything, Mr. Cutter, you wish to say?

STATEMENT OF L. R. CUTTER, CHAIRMAN OF THE BOSTON WATER BOARD.

Mr. CUTTER. — I suppose it is unnecessary for me to go over the whole history of the Water Works. I suppose you gentlemen are conversant with it.

Mr. GREENOUGH. — What does Dr. Blake think about that?

Dr. BLAKE. — I think not. I am quite familiar with the history of the Water Works, but I think Mr. Cutter might as well sketch the times when the water has been unpleasant to the taste.

Mr. CUTTER. — Of course, I have all the data. The investigation for a new source of supply began in 1871, when we employed

Mr. Joseph P. Davis to look over the various sources of supply, at a salary of \$5,000 a year, I think it was. He educated himself in relation to the different rivers and sources of water supply, and reported in favor of our taking the Sudbury river. We did take the Sudbury river, under authority given by an Act of the Legislature, and by subsequent authority of the City Council, as recommended by Mr. Davis. I believe I can state here that Mr. Davis' recommendations — I think every one of them, and my associates will correct me if I say anything that is not correct — were adopted by the Water Board, and that we never rejected any of them. We had confidence in him as a competent engineer, and we followed his suggestions. I know that in one particular he suggested to us the propriety of putting in pipes so we could connect the waters of the different reservoirs without mixing them together. He said it was a question involving about \$100,000, and it was for the Water Board to decide ; and the Water Board decided to put them in. So far as removing the loam was concerned, and excavating the shallow places, his recommendations were adopted by the Water Board, and I think some \$30,000 were spent in that way.

Mr. GREENOUGH. — Do you mean to state that Mr. Davis' recommendations were adopted in full by the Water Board?

A. Yes, sir.

Q. As regards the removal of the loam from the basins?

A. Yes, sir. After the basins were constructed, the Park Commissioners wanted some loam, — that is, after the recommendations came from Mr. Davis in regard to furnishing loam to the Park Commissioners from Basins 2 and 1. Basin 3, I think, was partly filled, and Basin 1 was, and Basin 2 was not so full, but it had accumulated considerable water. The dam, I think, was about finished at that time ; that was the last one finished. The Water Board thought that to draw the water down and excavate the loam at that time would jeopardize the city's supply in case we had a dry season, which afterwards proved correct ; and the water supply would have been jeopardized if the water had been wasted down the river, and we had begun removing the loam for park purposes. Of course, this removal of the loam is a question — no one can tell how far it is desirable to spend money in doing it. It may be good ; it may be of no good, excepting the looks and appearance of the basins. But, in Mr. Davis' report, he says that he recommends the construction of the dam to Basin 3 at the present time, while he thinks, perhaps, it will be three years before the city would need the water ; but that it would be necessary to construct it so that the grass, roots, and vegetation would have time to decompose, and in three years from that time the city would need the water, the decomposition would be gone through with, so much so that the water would be free from pollution from that source, or nearly so. But, owing to the dry season, we had to draw upon the first waters we filled that basin up with. Then, again, we have the loam in the shallow places, and the quantity of loam was more ; and, in Mr. Davis' report, he represents that there is more danger from that source in Basin 2 than in either of the other basins. Now, it has been proved that the

water in Basin 2 has been as good, been freer from *algæ* and better in taste, than in either of the other basins; and yet there is more loam and more shallow water there than there is in the other basins. If that is any argument, it is an argument to show that if we had removed the loam the same trouble would have existed, if you call it a trouble. So that it is a question that no one can tell about. But it does seem to me that if you go into the country and take river-water, — water that I, as a country boy, would never drink, and never considered fit to drink up in the country where I lived the first twenty years of my life, — and bring it into the city, I am a little surprised that you get as good water as you do.

Mr. GREENOUGH. — Do I gather from what you say that you do not consider river-water fit to drink?

A. We do not consider it fit to drink in the country — country boys do not, because they can get well or spring water.

Q. You were on the Water Board at the time this river was taken, were you not?

A. Yes, sir.

Dr. BLAKE. — Did you make any protest against it?

A. No, sir. I consider the Sudbury-river water as good as any river-water.

Q. Still, you consider river-water not fit to drink?

A. I did not say so. I said a country boy wouldn't drink it if he could get anything else. A country boy would drink it if he could not get anything else. But, then, the water improves in the city. I think I can relish the water better here to take it out of the faucet than to take it out of the basin.

Q. Do you object to it as a country boy because you know the sources of pollution?

A. I don't think it is very much polluted, except it is warm when it has been exposed to the air considerably. Spring-water coming out of the ground has not been exposed to the air, and well-water is not so much exposed to the air, and doesn't taste so well after it is exposed. But I don't know that it will harm anybody to drink it.

Q. Do you know that there is a prejudice all along the Sudbury river against using the water in the country through which it flows?

A. I don't know that that is a fact. In relation to Dr. Barnes' letter, that Dr. Blake just read, perhaps one word in relation to Mr. Bird should be said. Mr. Bird held the office of assessor in that town. Now, when we had claims for damages to settle, we were forced to go into court, and we cast around to see whom we could get to act as witnesses. So we took the Board of Assessors and summoned them in against their own will; but they could not help themselves, because they had assessed the value of this property. When we got them upon the stand they were the best witnesses we could get, — the fairest witnesses. But, as for Mr. Bird having been employed by the Water Board as a witness, it is not true in the sense in which "employing witnesses" is usually applied, and unless you call a man an "employed witness" who is summoned to testify against his will. Dr. Barnes alludes to Mr.

Johnson, who had suits against the city and wanted a large amount of damages, and we didn't think he should have so much.

MR. GREENOUGH.—I do not suppose the Board wish to state that there never has been any smell from any of those basins, do they?

A. They do not wish to state that there has been no smell from the gate-house where the water has been drawn out, of course, for we have experienced it there. There are strata of gases in waters, which emit bad odors, and they have been found also in Lake Cochituate. At a certain time, at a certain depth down, when you draw the water off, it would smell.

DR. BLAKE.—The Dr. Johnson referred to in this letter is in West Springfield street?

A. I have no doubt it is the son of the same man.

MR. GREENOUGH.—Do you consider the water in Boston good water to-day?

A. I consider the water good water. I have used it always. When my folks come down from the country-house, where we have a country well of as nice water as anybody, we drink this water down here, and my people don't complain of it at all.

Q. You are on the high service, I believe?

A. Yes, sir.

Q. There has been considerable difference between the water on the high service and that on the low service?

A. In different localities there seems to be a difference; yes.

Q. Now, I am on the low service, and in the water I find in my house there is a distinct muddy taste. It is not as offensive as the sponge or cucumber taste, but there is an unpleasant taste in the water. I should like to know to what you attribute that.

A. Well, I could say this much: In the country, in the spring of the year, when the frost is coming out of the ground and leaving the territory, there is a sort of taste in the brooks which we boys used to call a sucker taste, or frog taste,—a sort of ground taste. At that time the fish began to leave the ponds and run up the streams. In the fall of the year, when the frost begins to come and the temperature to change, that taste is perceptible then. It is a kind of ground overflow, as you might call it. It tastes something like this green frog spew, as the boys call it, in the country, that gathers in your trough, and it gathers in spring-water as well as river-water, and the smell is just the same as this.

Q. But there is a muddy taste and discoloration of the water also. The water coming from the low service now is yellowish.

A. The water coming now is none of the water from Basin 3; but it is from Basin 2.

Q. I know it; but it is not good water.

A. It is the river-water and has that color when it runs into the basin. I don't think it has any more color than when it leaves the basin. Now, last spring, when they began to complain of the water,—or some of them did,—I tasted it myself and followed it up pretty closely, and about every morning when I got up I tasted it before I tasted anything else; and we sent up and got a sample from the gate-house, and we also sent up to an old pond,

Mr. Rice's pond, on the same stream, less than a half a mile above and got a sample; and then we sent up to a brook which leads into them, and of those three samples the brook tasted the worst of the three.

Q. What was the taste?

A. Well, it was a sort of meadow-water taste. It tasted as if the water had run a considerable ways in meadow land.

Q. Was it free from *algæ*?

A. No; it was this spring before the *algæ* commenced to grow. The water seemed to be improved in Rice's pond, and also in Basin No. 3. The water all comes through Rice's pond to Basin No. 3.

Mr. SAWYER. — I believe we thought there were some *algæ* in the water at that time?

Mr. CUTTER. — In the brook-water it was a little more colored.

Q. But this best water?

A. No; I never saw any *algæ* as I know of.

Q. I thought we saw the *algæ* there?

A. That was before the *algæ* began to grow, I think; I don't remember. We saw that the brook-water was not quite so free of motes.

Mr. GREENOUGH. — I understand you to say that the water from which Basin No. 3 was fed was a little worse than the brook-water?

A. Yes, sir; I think it is called Angle brook. It comes down through considerable meadow land this side of Marlborough.

Q. What do you consider to be the purity of the Sudbury-river supply as to sewage? Do you consider that there is any sewage coming into the river?

A. Of course; there is a great deal of sewage, more or less, running into all rivers; but I do not think there is any great amount going into Sudbury river. It runs through a kind of territory — Hopkinton, Woodville, and other places — where there is not a great deal of pollution from sewage. If there are any sources of pollution, we have a report of them from the engineer, Mr. Fteley, in our office. Mr. Merriam has a woollen mill from which there is some pollution, on the Sudbury, in Cordaville.

Dr. BLAKE. — Where does the sewage from the Women's State prison at Sherburne find its way?

A. It finds its way down to Lake Cochituate.

Mr. GREENOUGH. — So far as sewage goes, Sudbury river is cleaner than Lake Cochituate?

A. I should think there is a good deal less sewage in the Sudbury than in Lake Cochituate, because Natick and Pegan brook are the worst sources of sewage that we have.

Dr. BLAKE. — For sources of contamination we have Pegan brook, Cochituate village, part of South Framingham, and the Women's prison?

A. South Framingham runs into Farm pond.

Q. But the others?

A. The others run into Lake Cochituate. The Women's prison has not been so bad for two years past; I believe the State has spent twenty or thirty thousand dollars there in utilizing the sew-

age or purifying it, so that they think it does not harm our water.

Mr. GREENOUGH. — That is all strained out before it passes into the brook which runs into Lake Cochituate?

Mr. CUTTER. — Yes, sir.

Dr. BLAKE. — What is the process of filtration?

Mr. GREENOUGH. — It is used in irrigation. I haven't seen it, but I think the water in the brook shows no sign of sewage.

Mr. CUTTER. — No; I do not think it shows any sign of sewage. Sometimes we think perhaps there is a little bead on the water like frost.

Dr. BLAKE. — Has it ever been analyzed?

A. No; I do not think there has been an analysis of it since the State has spent that money.

Q. Do you notice any change in the Sudbury-river water to-day from what it was when the city first took it? Is it more highly colored, or does it taste different?

A. I could not say. It rather looks fully as high colored as the first time you saw it.

Mr. GREENOUGH. — You were on the Board when the Sudbury river was taken?

A. Yes, sir.

Q. You expected at that time that the water from Sudbury river would have that high color?

A. I think it was understood that storing it in the basins would bleach it out.

Q. Has it been bleached out?

A. I do not think it is as yellow as it is when it comes in, especially after it comes from the reservoir at Chestnut Hill.

Q. The reservoirs at Chestnut Hill are entirely filled with water from Sudbury river?

A. Not necessarily so.

Q. More so than the Brookline reservoir?

A. Yes, sir; more than the Brookline reservoir.

Q. Is there any muddy deposit in the reservoirs at Chestnut Hill?

A. Not much, to our knowledge. We cleaned out the Brookline reservoir two years ago. We thought we should find some fish and sediment in it, but we were surprised to find it was so clean; and, in fact, it did not pay to clean it out, except that we had a chance to repair our conduit around to it and bind it up, which it seemed to need. One man said he would give us two hundred dollars for the fish that were there; but the fish we got did not amount to anything; we didn't get two bushels full, to my knowledge.

Q. That basin has always been filled from Cochituate water?

A. Not always.

Q. Practically, there never has been anything there except Cochituate water?

A. Probably more so a great deal than the Sudbury.

[At this point the City Engineer produced two glasses of water, one from the high and the other from the low service. Upon the samples being tasted it appeared that the one from the low service

had a strong taste of mud, and that from the high service was free from such a taste.]

Mr. GREENOUGH. — But the water in Lake Cochituate is clear; there are no *algæ* in it?

Mr. CUTTER. — We have had it shut off since we have had basins to supply the city. We have had to shut off Lake Cochituate from some time in January to some time in July — I think that was in 1880 — because of the cucumber taste. Then we had to shut off the Bradlee basin some five years ago, for some three months, I think, in the winter, because it had a strong cucumber or very bad taste; but that came around all right, and so did Lake Cochituate, and we did not have to waste the water.

Q. This water you are now supplying to us comes from Basin 2?

A. Yes, sir.

Q. That is as good water as we can expect to have from the low service?

A. Not necessarily so.

Q. That water is comparatively clean, although it has a slight tinge?

A. We are not obliged to supply the low service with that water. We can supply it to the Brookline reservoir, and can supply Chestnut Hill with the lake-water, if we choose.

Q. Well, the main supply being drawn from the Sudbury river, that water is as good as we can expect to get from the Sudbury river, is it not?

A. I could not say how much better it will grow, but I suppose it is as good as you can get to-day.

Mr. SAWYER. — Does Mr. Greenough mean to ask if what we get from Basin 2 is as good as we can expect to get from Sudbury river?

Mr. CUTTER. — No; whether the water we get from Sudbury river is as good as we can expect to get.

Mr. GREENOUGH. — You detect the muddy taste in that water?

Mr. CUTTER. — No, not appreciably. If you should hand that to me in the dark I don't think I should distinguish it. But I see there is a trifle difference.

Q. Do you consider that satisfactory water?

A. I consider it satisfactory if you cannot get any better. If you could, we should like to have it.

Q. Do you think it is as satisfactory water as can be got from Sudbury river?

A. I think if that water could remain longer in the reservoir it would be better. We are drawing it now pretty fresh from the stream.

Q. That is to say, if our supply was more ample, so that the water could be allowed to stand longer, then the water would improve?

A. Yes, sir; if we had our different dams constructed so we would not be obliged to draw from a basin that takes the water direct from the river, it would improve the water.

Q. The water would improve if the supply was increased or the demand diminished?

A. Yes, sir.

Dr. BLAKE.—Or the number of reservoirs increased?

A. Yes, sir.

Mr. GREENOUGH.—But your recommendation is now that the city should decrease the consumption, rather than increase the supply?

A. No; it is to increase the supply.

Q. I read in your report that it was desirable for the city to decrease the consumption.

A. But we recommended the construction of an additional basin.

Q. After Basin 4 is finished, that it would be advisable to secure the land for another basin?

A. Yes, sir.

Q. And you give, as a recommendation of the Water Board, now, both the increasing of the supply and diminishing the consumption?

A. Yes, sir; that is our duty.

Dr. BLAKE.—Have you been able to demonstrate that allowing water to stand a long time—two or three years—would render it more satisfactory and improve the taste and color?

A. I think so, from the fact that Lake Cochituate is of a better color and the taste is different.

Q. Its source is different?

A. It has brooks running into it.

Q. Its bottom is different?

A. Yes; but there is Pegan brook running into it. It has more pollution running into it than the river.

Q. But it is not river-water?

A. No, sir; it is spring-water.

Q. And it has been quite clear and almost tasteless?

A. Yes, sir.

Q. And, on the contrary, Sudbury river has always been brown and highly colored?

A. Yes, sir. I think that where I live I don't experience any such trouble as Dr. Barnes has had about trouble in the tanks. I live on Hancock street, about half way between Derne and Cambridge streets. It is about the lowest part of the high service. We use the pipe so little that the water which comes into our house is comparatively free from sediment. That is the reason I get so much better water than you do in your street, Mr. Greenough.

Mr. GREENOUGH.—Still, the high service is supplied from Cochituate?

A. More so.

Q. And when that fishy taste was so prevalent last year, if I remember aright, the high service did not experience but a little of it?

A. We only had it two days.

Mr. WIGHTMAN.—That was simply from the lifting of the gate,—that is all.

Mr. GREENOUGH. — As a matter of fact, when the city was complaining last year of the cucumber taste, the high service did not experience it. Both the members of the Water Board who live on the high service did not appreciate the character of the water the people were drinking, and it seems that Mr. Wightman gave them a taste of it.

Mr. WIGHTMAN. — I believe the Chairman of the Water Board did not like it.

Mr. GREENOUGH. — I want to ask you, Mr. Cutter, whether, as Chairman of the Water Board, you think the laws in regard to the purification of the water supply are satisfactory ; and, if not, why not ?

A. No, sir ; they are not satisfactory to me. I think we ought to have a law that will prohibit bathing to a considerable degree, and also to prohibit boating to such an extent that the Water Board ought to license all boats, because boats used by boys and people that do fishing nearly always have bad water in them that makes a nuisance. Then I think we ought to have a pretty strong law, to prevent pollution. We have a law that is pretty strong until we come to a jury. We can go to the State Board of Health, and we did go against the town of Natick, and took five of our best cases, and the Board gave us the case, and enjoined them. Then they appealed to a jury and we had a trial in the Town Hall, which was filled with people from about there, and the sheriff ruled in their favor, and we had no show at all, and the case was decided against us. The sheriff ruled that if the water was not good when running into the other end of the lake, where it went out to go to Boston it was all good. Then we took an appeal to the Supreme Court, which decided in our favor ; but the Court did not enlighten us. We had taken an exception, and contended that the Board of Health should be present when this trial before the sheriff's jury took place ; but they were not notified to be present. The Supreme Court took that one item and decided it in our favor, and left all the other items undecided. The law is that we enjoin the individuals, and not real estate, and, therefore, all they have to do is to change tenants and owners, and they slip out of our hands again. So the law is not very effective.

Q. You consider, as Chairman of the Water Board, that you have taken all the measures you can to purify the water supply, but you are prevented from being successful from the lack of a proper law ?

A. We certainly have exercised all the zeal in our power in that respect.

Dr. BLAKE. — So you have no additional recommendations to make or suggest toward improving the quality of the water ?

A. Of course, we should recommend a different law ; but we are met by saying, that if we go up to the Legislature and recommend a different law, we will not get as good as we have got. In our experience up there, it has proved somewhat so. Malden suffered by people trotting horses on their ice in Spot pond after the snow had gone. They would go out there with four or five hundred sleighs and trot on the pond, and when there came a thaw the

water on the top of the ice would be of the color of coffee. They wanted to prohibit that, and came to us, and we said we would also like to prohibit bathing in the waters used for our supply. They said they would add that on. We went up there and worked together. Finally, they came to me and said if we didn't leave off that bathing clause we should not get anything, and if we left it out the other would go through. Of course we would rather take a half loaf than none at all, and we left it out; and of course we got it. That was on Spot pond, which is the supply for Malden.

MR. GREENOUGH.—It wouldn't do you any good at all?

A. It did us so much good that prospectively they cannot trot on Lake Cochituate or Farm pond.

Q. They never did do that?

A. No; not to any extent.

Q. Have you anything else that you wish to state, to go on record from your Board?

A. Any suggestions?

Q. Any suggestions or any statement in regard to the taste and character of the water supplied to-day. You are aware, of course, that the Water Board has been criticised in the papers and by the public. Have you anything you wish to say in answer to that?

A. Well, in answer to that I can say that the water of Boston is as good as that of any other city in the United States, and will average as good, if not better. You must know that when we are called upon to furnish forty millions of gallons every day, we cannot strain it and filter it every day before we let them have it, because the quantity is too large. But we have done the very best, under the circumstances, that we could, and have acted honestly and done the best we could with the facilities we had to work with. We, of course, might have gone to work and spent \$100,000 in removing the loam, and, sentimentally, we would stand better to day; but, in a practical, business point of view, I am not sure we haven't saved the city \$100,000, because the water might not be better, for the evidence to-day is that Basin 2 is better than the water that goes into it.

DR. BLAKE.—If you were going to work to prepare a system to better the water, how would you go to work to store it if you had to save the rain-water and store it for some time? Would you cement the sides of the basins, or leave them open clay?

A. We should have to cement them to hold the water in. I suppose your question is, whether I thought a muddy bottom would improve the water. Now, Mr. Norman says the best water is found where the bottom is muddy. He has had as much to do with water as anybody in this country. The fact that the Lawrence basin is muddy, and the water never tasted bad, and the Bradlee basin being gravelly and the water tasting bad, corroborates his statement.

DR. BLAKE.—That would depend upon whether the water which entered these basins was pure in character.

A. It went into the Lawrence basin first, and from that into the Bradlee basin, and both came from Lake Cochituate.

Q. It doesn't seem to me quite reasonable to suppose that a

great, powerful solvent like water is not going to dissolve organic matter and hold it in solution. I think it might as well be admitted here that it does affect its taste to some extent.

Mr. GREENOUGH.—I was going to ask Mr. Cutter something to that effect, and also Mr. Wightman. What do you consider to be the effect upon water when it is first let into these basins? Doesn't it take a considerable amount of vegetable matter?

Mr. CUTTER.—I never supposed you could get as good water from a new basin as you could from an old one.

Q. How old ought a basin to be for the decomposition to go through with?

A. I should say three years, certainly.

Q. You advise the building of the basins ahead?

A. Before we want the water.

Q. But, as a matter of fact, you have been obliged to use the basins as soon as they are done?

A. Yes, sir.

Q. When were Basins 2 and 3 constructed, do you remember?

A. Basin 2 was the last one filled, in the fall of 1879 and spring of 1879. Basins 3 and 1 were filled the year previous.

Q. Well, now, you expect to give us the water from Basin 4 as soon as it is completed?

A. Not unless we have a dry season.

Q. What do you expect is to become of that water? Basin 4 is on the Sudbury river, is it not?

A. Yes, sir. I think the water will purify itself if allowed to stand long enough?

Q. You cannot run that water to waste except through Basin 2?

A. No, sir.

Q. What do you expect will take place in that basin after it is filled with water?

A. I expect the same effects in that basin as you see in Basin 3, — that the *algæ* will grow in it.

Q. At first?

A. Yes. I don't know what will cause the *algæ* to grow; nobody knows; because we have seen *algæ* grow in old ponds where no sewage goes into them, nor any filth. We see them grow in pure spring water, up here in Woburn, and we see it pumped up from the spring.

Q. Why do you think the water is going to be any better after lying there for three years?

A. Because I think the vegetation will decompose, and the grass and roots and everything of that kind die. Of course we cleaned out Basin 3 and burned it out as best we could, with the exception of scraping out the loam and gravel; but so far as the vegetation was concerned it was all cut and burned. But it was a dry season.

Dr. BLAKE.—You not only had the decomposition, but the settling and precipitation of this matter to the bottom?

A. I suppose the impurities settled to the bottom.

Q. And if you have it stand long enough that is the process you expect?

A. Yes, sir; but I am not a scientific man, and cannot tell exactly.

Q. I know; but you understand that process very well. If you have a small amount of clay or earth, or anything in that water, let it rest long enough, and the thing settles, and then you hope to draw the water above that?

A. Yes, sir. It is like drawing a pitcher of water in St. Louis; if you let it stand the gravel in it settles to the bottom of the pitcher.

Dr. BLAKE.— And then the exposure to the air brings about purification?

Mr. GREENOUGH.— Then what you say is practically this: that, in your judgment, a basin ought to stand three years before the water is used?

Mr. CUTTER.— Yes, sir.

Q. And you have never been able to let it stand at all, before this?

A. Yes, sir.

Q. And if nothing is done to decrease the consumption you will find it necessary to use the basins as soon as constructed?

A. Yes, sir, unless we have a wet season; in such a season as we have had for the last three years.

Q. And if the consumption keeps on at its present rate?

A. Yes, sir.

Dr. BLAKE.— Then your views remain unchanged, that we have no reason to expect an improvement in the quality of the water in the near future?

A. I think the water will improve in these new basins already constructed.

Q. How can it improve in the basins?

A. From the very fact that most of the basins have now been constructed three years.

Mr. GREENOUGH.— The water in Basin No. 3 is as bad to-day as it ever was?

A. No, I do not think it is as bad to-day as it was last season.

Dr. BLAKE.— Is it not as bad to-day as it was last summer?

A. No, for the reason that we were obliged to draw it down last summer, which naturally had a bad effect on the water.

Q. But you are an expert in water; isn't it your opinion that if you could allow the water to stand in those basins to some extent, it would prevent the disagreeable effects which follow the exposure of those margins to a high temperature?

A. I think the absence of the sun's rays would prevent it.

Q. So that if we had a sufficient number of basins to allow the water to stand during the summer, and could, in the meantime, get our water supply from some other source, we might not experience the same result in hot weather?

A. Yes, sir.

STATEMENT OF CITY ENGINEER H. M. WIGHTMAN.—*Continued.*

Mr. WIGHTMAN.—There have been certain questions asked by this Commission which I have answered, and have since taken the pains to get at more accurately.

This question of shallow flowage seems to be one that by general consent influences the quality of water as much as any other. I really do not know how to avoid it, except at large expense. You may take any large pond, or large lake, and it always has more or less of this shallow flowage, and usually the percentage would not vary as much as would be supposed.

I presume this Commission, and the Water Board too, would have an idea that Lake Cochituate had very much less shallow flowage than any basin in the Sudbury. But the fact of the matter is, it has not so very much less as you would suppose. I have had some figures made showing the percentage of shallow flowage in Lake Cochituate, Basins Nos. 1 and 2; Basin No. 4 I have not got.

In Lake Cochituate the water area at high-water mark we call 800 acres. The shallow flowage line I have assumed to be at 5 feet in depth, as anything lower than that would be quite shallow; and the average is 184 acres of shallow flowage, or 23 per cent. of the total water area.

Basin No. 1, 149 acres, averages 58 acres of shallow flowage, which would make $38\frac{9}{10}$ per cent. That basin has the most shallow flowage of any. We have never considered that basin a proper source to draw from except in case of an emergency. It was a necessity to put it there, because we had to commence the conduit at that point. But the basin never was considered by Mr. Davis as a very desirable one to build; but it was built as a necessary part of the scheme.

Basin No. 2 has 136 acres, 31 of which are shallow flowage, which is 23 per cent., or 22.81 of the total area.

You see that Lake Cochituate and Basin No. 2 are very nearly alike.

I made a statement that there is as much shallow flowage in proportion to area in Basin No. 3 as there is in Basin No. 2, but that is not quite correct. In Basin No. 3 there are 283 acres, with a shallow flowage of 79 acres, which makes 27.9 per cent.

You see Lake Cochituate has 23 per cent.; Basin No. 1, 38.9 per cent.; Basin No. 2, 28.81 per cent., and Basin No. 3 has 27.9 per cent. Basin No. 4 will have much less than that, even less than Lake Cochituate.

Mr. GREENOUGH.—Supposing that 5 feet to be 8 or 9 feet, how would it be affected?

A. I think the same proportions would hold, except in Basin No. 1, where it would be very largely increased.

Q. Is there not a very large amount in Basin No. 3 which would be left with very little water on it at five feet?

A. No, there is not a very large amount of it. I do not think it would increase that percentage.

Now, as regards this question of *algæ*, about which I have been asked some questions by the Commission. The matter has been

pretty thoroughly investigated by scientific men. While I think their opinion is that it is generally caused by the shallow flowage, I do not think with many of them that it is caused solely by shallow flowage. At any rate, Lake Cochituate is quoted as being a pure source of supply; and yet it has as much shallow flowage as Basin No. 2, and within five per cent. of the shallow flowage of Basin No. 3.

As regards *algæ*, I have known Lake Cochituate twenty-five years, and there have not been three years out of the twenty-five that I have not been there, and I have never known any year that the *algæ* were not in the lake,—in some portion or the whole of it,—and usually it would occur twice a year; not always, but usually it would occur twice in the year.

As regards Farm pond, of which so much has been said to this Commission by Dr. Barnes, who thinks the appearance of the *algæ* dates from the introduction of the Sudbury-river water, there are old residents of Framingham, who have lived on the borders of this pond for years, who can furnish information that that pond has always been affected by *algæ*. There is one gentleman living on the border of the pond who has known about the presence of *algæ* for forty years. I think he would testify to this Commission that there has been no year in forty years that there have not been *algæ* in the pond. Lake Cochituate and Farm pond are natural ponds, and also Horn pond, which is largely a source of supply. I suppose the water of Horn pond has a reputation all over the world; it has been shipped everywhere in the shape of ice. It is a pond of one hundred acres, with an average depth of twenty feet. Yet the first trouble we had with *algæ* originated in Horn pond, and was localized there, and drifted down to Wedge pond, and from there into the Upper Mystic. There have never been any in the Abajonna river, but I have no doubt they have been in the ponds there.

Mr. GREENOUGH.—*Algæ* do not occur in running water?

A. Apparently not, to any extent. There are at least a dozen kinds of *algæ*. The report of the State Board of Health of 1879 has a very able paper by Dr. Farlow, giving their names and showing the great variety of them. The *algæ* causing this trouble can be classed among the *Nostoc* family. I do not think anybody knows whether the presence of these *algæ* is injurious to health; no scientist of reputation has yet been prepared to state positively that it was.

As regards these *algæ* in Basin No. 3, there is rather a curious thing about that, which, perhaps, illustrates what Mr. Cutter says, and which is the generally received opinion among engineers, that in building a basin of that kind the water should be stored two or three years before it is used, especially when there is cultivated land, or any land where there is much matter to decompose. You asked Mr. Cutter a few minutes ago whether the water in Basin No. 3 had not been about as bad this year as last. I do not think the water in Basin No. 3 has been as bad this year as it was last year. The appearance of the *algæ* dates later, so far, every year, and this year it has appeared later than any other. I think that goes to show

that it may eventually die out. If you should visit Horn pond or Wedge pond to-day you would probably find the *algæ*. It was so yesterday. Last year the same thing appeared nearly two months earlier; the year before that it was earlier still. So it seems as if the thing might possibly disappear for a time.

Mr. GREENOUGH.—It has not disappeared even in Lake Cochituate?

A. That is, it may disappear for a term of years, and then reappear again, perhaps. I do not know how it will operate in the basins, but in Lake Cochituate I have not seen a year in twenty-five years when it was free from *algæ*.

Q. If that basin could be kept for three years and then all the water run out of it and wasted, probably it would be much better for the basin?

A. I do not think it would be absolutely necessary to waste the water. Of course these organic matters decompose and are oxidized by the air and water, and I do not know why that would not be as good water as the basin filled up again. For instance, when the Chestnut-Hill water was badly contaminated by the *spongilla*, the water was isolated for two or three months, at the end of which time I was not able to see that the water did not taste about as good as ever. It had a flat taste, that is, it lacked air. But there was no discoloration and no muddy taste. So I do not think it would be absolutely necessary to waste that water. I think the effect of the oxygen in the water would decompose all those matters and settle them in such a way that the water would be, perhaps, purer than if we let fresh water into it.

Q. How long do you think it should stand before you should use it?

A. At least two or three years; but that cannot be in the present state of our supply. We are to-day at the limit of our supply, practically, in a dry year. As you know, last year, if it had not been for our getting some six hundred million gallons from another source, which we did not expect to get, we should have been just that much short of our supply, notwithstanding all the notices issued to people about being careful in the use of water.

Q. So you consider it necessary that we should either increase our supply or decrease our consumption?

A. Yes, sir, decidedly.

Q. And of course decreasing consumption is the cheaper means of the two?

A. I think so.

Q. Will you instance some cases in which *algæ* have appeared in water perfectly pure and uncontaminated?

A. Yes, sir; there are two cases pretty close to us, and well known by parties familiar with the subject. For instance, when the water works were first established in Brookline they took their water from what is known as Cow Island, lying in Charles river, between Dedham and West Roxbury. They dug a channel in the Island, which they stoned up loosely at the side, and turned an arch over it. They took ground-water, of course. From there it was carried in pipes to their pumps, and it was pumped through pipes

some two miles long to a reservoir on Fisher's hill. Whenever I have seen that reservoir — and, in fact, I guess you will find it so to-day — it has always been in what you would call a filthy condition ; that is, it is filled with *algæ*. It is built with earth banks and lined with stone. Two-thirds of it was excavated out of the solid ground. The bottom and sides were of clay and lined with masonry.

Q. And you would think the *algæ* came into it with the water?

A. I do not know. I know that in tube wells it was impossible to keep them out.

Q. What was the other case?

A. The other case was the Horn-pond water works, which supply the town of Woburn. I laid those works out, and made the original report for the town of Woburn. It was intended to take the water direct from Horn pond, and the gate-house was located on the borders of the pond. But when they came to locate the pump well, they found there was an enormous quantity of water running apparently towards Horn pond, but the temperature was 10 to 15 degrees lower than that of Horn-pond water ; that is, if it was 70 in the pond, the average temperature of this water was 50 to 55. When they found they had so large a quantity of water, they built a short gallery, to take it direct to the pumps and pump it into their reservoir on a hill which is on the site I selected, — a regular rocky gorge, and all it required was a dam at one end. That was all cleared off and a dam built across the end and the water pumped into it. I think that if you visit it to-day you will find the water filled with *algæ*. It has been so every year, notwithstanding it is kept in what is called a rock reservoir. Those are the two cases I am most familiar with, and the ones about which the Commission could obtain any quantity of evidence to corroborate mine, as to the presence of the *algæ* in the water.

Q. Do you know anything about Wenham lake?

A. Yes, sir ; I examined it for the city of Salem ten or fifteen years ago.

Q. Did they find any *algæ* in that?

A. I do not think there was, although the amount of water they use is quite small, and there might not be sufficient *algæ* in it to trouble them. The temperature of the water is always low.

Dr. BLAKE. — The development of *algæ* is a question of temperature ?

A. Yes, sir.

Mr. GREENOUGH. — Whether it is your opinion that *algæ* would appear in any water exposed to the sun ?

A. I think it would. The temperature of the Sudbury-river basins is now about 60°.

Dr. BLAKE. — And what is Lake Cochituate — about the same ?

A. Yes, sir ; it is about the same.

Q. And fed by springs ?

A. It is fed by ground-water. I do not think there are any springs there. I do not think the water comes from a great distance; that is, there are no deep-seated springs. The ground-water may come for miles. If it is porous ground when you draw the water down, you draw it from the entire country around; and when you fill it up, you fill the country again. I pumped Lake Cochituate in 1871 the first time; of course we kept expecting that the springs would develop themselves to some extent, but I never noticed that any appeared. We could draw the water from the wells in the country around, and we did take the water out of them. But the water was drawn down about fifteen feet, and you could not find any places where there were any signs of springs. I doubt very much if there are any springs there.

Mr. GREENOUGH. — Are you familiar with the water supplies of other cities of this country?

A. Yes, sir; I have visited most of them.

Q. Are they troubled with *algæ* in the New York City supply?

A. I could not state as a fact that they are.

Q. Do you know anything about the preparation of their basins?

A. They built their basins just as we did; but the country they built in is much more rocky than the Sudbury district. There is less cultivated land in proportion to the area of the basins.

Mr. SAWYER. — They have had the cucumber taste there?

Mr. WIGHTMAN. — I am not sure whether they have or not.

Mr. SAWYER. — I think Prof. Remsen said so in his report.

Mr. WIGHTMAN. — They had it in former years, I think.

Mr. GREENOUGH. — Has there been any difference in the preparation of the basins on the Sudbury from the plan of other cities?

A. No, sir; I suppose there are a dozen towns in the immediate vicinity of Boston which are supplied in the same way, and the basins were built in exactly the same way. The town of Arlington is supplied in the same way, and has a very shallow basin. The town of Winchester has a similar basin. In these cases they simply build the dam across a valley.

Q. And strip off the loam?

A. They do not strip off the loam.

Dr. BLAKE. — And they have the same trouble. Out at Winchester, I understood, the water was so bad they could not use it.

Mr. WIGHTMAN. — Prof. Remsen makes the following statement:

Last winter, also, the Croton water of New York became affected in the same way. We have abundant records to show that the "cucumber taste" has affected waters in many other places. I may mention, for example, the following other places: Hartford, Conn., 1871; New Haven, Conn., 1864, 1865, 1872; Norwich, Conn., for several years in succession; Jacksonville, Ill.; Holyoke, Mass.; Lynn, Mass.; St. Paul, Minn.; Keene, N.H.; Albany, N.Y.; York, Pa. Many other places might be mentioned; but the above will suffice to show that the difficulty is not confined to one section of the country.

Mr. GREENOUGH. — You have no doubt that the cause of the cucumber taste is the *spongilla*?

A. I have not the slightest doubt of it.

Q. And that it is such a thing as may come into our water supply at any time?

A. It is liable to.

Q. And the only way to free our water supply from that taste is to have an excess of supply?

A. It is the only way I know of.

Q. I suppose the Sudbury and Cochituate supply, as it comes to-day, is as good as it is likely to be, as long as we are unable to store it?

A. I think so.

Q. Now, sir, I want to ask you in regard to a question which I am not sure may not be of importance. I think I showed you a letter written to me by Dr. Lyon Playfair, some months ago, when the Commission were talking about going to Lake Cochituate, in which he says:—

It may be that you require filtration through oxide of iron to burn up this organic matter.

I also want to recall to your recollection the conversation we had with Sir Frederick Bramwell, in regard to the universal filtration of the water supplies of the English towns before it is used, and stored in small quantities before it is actually put into the supply. Have there been any experiments of that kind made in this country on a large scale? Not in filtering through a sand bank or gravel bed, but filtration through a regular filter, at the rate of thirty or forty million gallons a day, for the purpose of removing organic matter?

A. No, sir. There are no artificial filtering works in this country except those at Poughkeepsie. Mr. Kirkwood, quite a number of years ago, was sent to Europe to investigate the question of filtration; but his conclusion, and that of others of the best engineers in this country, was, that it was impracticable, on account of our climate, to carry out any system of filtration similar to those in Europe.

Q. Why?

A. Simply on account of the cost, the great expense of maintenance, and the difficulty of keeping the works free from ice. There is trouble of their clogging with *algæ*. If you take water, such as it has been here, a filter would clog; we would have to have four times the area to take care of our water in consequence of this *algæ*. We made enough experiments to show that the filters would clog in an exceedingly short space of time when the water was full of *algæ*. Notwithstanding all the study given to the subject since then, there has never been but one place which has attempted to introduce it, and that is Poughkeepsie. I do not know whether it is a success or not. But the filters were constructed upon the best plan, under the supervision of Mr. Kirkwood. There are plenty of filters in this country which are failures. The town of Brookline attempted it at Cow Island, and had to abandon it, and take water direct from Charles river. The city of Lowell built a filtering gallery, and for a few years it answered very well;

but it began to clog up, and in time it was found impracticable to get water from that gallery. They thought they would put in an artificial gallery, and that did not work but a little while. So now they take the water directly from the river.

Q. And distribute it through the system of pipes?

A. I asked Mr. Francis about it. He says they practically distribute it as received from the river; but it stays in the reservoir a certain time, and much of the sediment settles out of it. I should think it would be bad. I used to visit out to Chelmsford, and between there and Lowell was boating and fishing on that river five or six weeks in the year, and saw the water at various stages of the river. I should think it would be usually very dirty for drinking-water. The book referred to is published by Mr. Kirkwood.

Q. Did he consider the question of filtration by oxide of iron?

A. No; I think not. You know what Sir Frederick Bramwell said the other day, or what Mr. Davis said in conversation with him: "I know they did have such a system at Berlin, and it was abandoned on account of the ice."

Q. Of course they would not be likely to be troubled with *algæ* in the winter?

A. No, sir; in the summer season they are troubled with *algæ*, and in winter with ice.

Q. But they were using oxide of iron at Berlin?

A. No; I think it is only the ordinary system of filtration. In regard to that system of filtration by oxide of iron, I have always been of the opinion that a complete aeration of the water would improve its color and quality.

Dr. BLAKE.—Is there any way by which the water supply can be more aerated than it is now?

A. I think if we built a conduit across Farm pond I should make some experiments on that. I have talked with a good many parties about it, and I am more than ever convinced that something of that kind should be done to improve the water.

Mr. SAWYER.—Don't we think the conduit should be built across Farm pond?

Mr. WIGHTMAN.—That is what we do think.

Mr. GREENOUGH.—Do you suppose there is any one in this country who knows anything about the system of filtration by oxide of iron?

A. I do not think there is. It is only done on a small scale.

Q. Those English water companies must be accustomed to handling as much water daily as we do.

A. But they have half-a-dozen supplies. They may not take half as much water from any one source as we do.

Q. But there are seven times as many people, and each company must supply more people than we do. They must be in the habit of handling large quantities of water.

A. I guess not as large as thirty or forty million gallons a day from one source.

Q. Although the Cochituate sometimes has *algae* in it, and sometimes *spongilla*, it has not this organic taste to it which the Sudbury has, and it might be necessary to filter only the Sudbury.

A. Cochituate water is stored longer. I think if the Sudbury water was stored as long as the Cochituate, it would taste as good as the Cochituate, particularly in the new Basin, No. 4.

Dr. BLAKE.—Is there any difference in the character of the living water and stored water?

A. That brings up this very question of aeration. I think there is a difference.

Q. Have you stated before this Commission any reason why, in your opinion, there should be a difference between the water in Basin No. 2 and Basin No. 3; why Basin No. 2 has so few *algae* and Basin No. 3 so many?

A. No, I do not know any reason why it should be, except, of course, there are very much larger bodies of water running through it; but they are not any larger than runs through Basin No. 1. The same quantity of water runs through Basin No. 1 when it goes over the dam, and yet the *algae* invariably appear in Basin No. 1.

Q. The character and preparation of the basins is substantially the same?

A. Yes, sir, practically.

Q. The same amount of shallow flowage?

A. Within 5 per cent.

Mr. GREENOUGH.—What have you got to say in regard to this pigpen odor which Prof. Remsen refers to?

A. There has been a smell up there from time to time, but it is no more than you would smell from any fresh-water pond when drawn down. You get the same smell when the pond is drawn down. You get the salt-water smell from the flats when the salt-water is drawn off. You invariably get it when the water is drawn down and the bottom exposed.

Q. Now, I wish you would, if possible, make an experiment in regard to this purification. Sir Frederick Bramwell spoke of purifying the water and taking the organic matter out of it by the iron slag which comes from the furnaces, or something of that kind; and it would be very easy to make a small experiment.

A. Well, you have the letter of Dr. Playfair.

Q. Yes, that is oxide of iron and charcoal. But Sir Frederick Bramwell says he is a member of a company, and he suggested that his word might be taken with a grain of salt; but he said they had been extremely successful, and he gave me a pamphlet showing what beautiful water they had been turning out after it passed through this iron. It might be possible and worth our while, leaving no stone unturned, to see if it would not be possible to get

some figures as to the quantity necessary, absolutely, to purify the Sudbury system. Do you think it would be possible to do so in the course of a month?

A. I do not know why not. I will say that we have tried sufficient experiments with ordinary filtration to show it is entirely impracticable, especially when there are *algæ* in the water. It would be impossible to erect the works without an enormous cost. To filter ten millions of gallons a day would cost at the rate of four hundred thousand dollars for the plant alone. Multiply that by four and you will see what it comes to.

Q. What has been the average consumption the past year?

A. About thirty-one millions.

Q. That is, the Sudbury and Cochituate together? You have taken about eighteen millions from the Sudbury?

A. Yes, sir.

Q. The water was filtered in what way, in your experiments?

A. Through regular sand filters, of the ordinary form. That report was made by Mr. Davis, and is in print. I may not state the figures right, but I can get them.

Dr. BLAKE. — I wonder if Lyon Playfair expected to discolor the water as well as purify it by this change?

Mr. GREENOUGH. — I should judge it would take out just this difficulty which we found in the water here.

Mr. WIGHTMAN. — The water loses its color entirely in storing. It keeps growing lighter and lighter in color.

Dr. BLAKE. — Is it not a fact that on the Continent they cover all their storage-basins?

Mr. WIGHTMAN. — Yes, sir, they are obliged to. They cover the filtering-basins, and the distributing-basins also.

Q. Is it not also a fact that they are getting rid pretty rapidly of all the shallow basins and making them very deep?

A. I understand they are, as a rule.

Q. So that they want to avoid the effect of temperature upon the water?

A. That is the object.

Dr. BLAKE. — After all, Mr. Chairman, it seems to come down to a question of temperature.

Mr. GREENOUGH. — In the production of *algæ*?

Dr. BLAKE. — Yes, sir.

Mr. WIGHTMAN. — Here is the report of the State Board of Health for 1879, in which there is a report by Mr. Fteley, which is of interest as showing the experiments made (page 123). Prof. Farlow's report commences on page 131. In that report he goes into it very thoroughly, as you will see. It will be useless for me to read it. There is also the report of their correspondence in relation to the effect of *algæ* in the Mystic-water supply. There is one thing that Prof. Farlow does here to which I wish to call attention. He calls Horn pond a very filthy basin; but I am sure I do not know for what reason, because it was always considered one of the best ponds in the vicinity of Boston. Simply because it had *algæ* in it, he thinks it is very filthy. He seems to think it a bad pond, anyway.

But there is more information upon that question of *algæ*, of the different kinds, how they grow, etc., and it is the best information on the subject that I know of,—in fact, it is the only thing that has been written that amounts to much on that subject.

There is a report that I wanted to call attention to. I stated some figures a few moments ago about the cost of filtration. Mr. Davis gives these figures in his report, on page 34 of the fourth annual report, 1880. The report was written in December, 1879, and was reprinted in the report which I made to the Water Board of that year. Without going into details, perhaps a few extracts from it will answer. He gives the different methods of filtration, and finally says (page 35) :—

The estimated cost is, therefore, for artificial filters constructed on the European plan, and consisting of two feet of fine sand, one foot of coarse sand, one foot of fine gravel, and three feet of coarse material placed in layers in masonry reservoirs or tanks. To filter 10,000,000 gallons daily, and to provide a surplus area that the process of cleaning may be carried on without interruption to the supply, seven beds, each having an area of about 33,000 square feet, will be required,—allowing an average flow of fifty gallons per square foot per day.

The relative levels of the lake-surface and the existing conduit are such that pumps will be required —

(We should, practically, have to do the same thing on the Sudbury and Cochituate.)

— to lift the water from the lake to the filters, which last will deliver the filtered water to the conduit by gravitation, and are to be situated near the gate-house, at the upper end of the conduit, where good sand and gravel for forming the beds are found.

The estimated cost is as follows :—

Inlet chamber and pumping-station	\$120,000
Filters, tracks, washing beds, etc.	250,000
	<hr/>
	\$370,000
Add ten per cent. for superintendence and contingencies	37,000
	<hr/>
	\$407,000
Add land damages, say	20,000
	<hr/>
	\$427,000

That is for 10,000,000 gallons on the Mystic. That is about what I stated from memory (reading) :—

The cost of pumping and of operating the filters would be about five dollars per million gallons of filtered water.

The interest upon cost of works at five per cent. would be nearly six dollars per million gallons, making the total cost eleven dollars.

Then he goes into the question of expediency. He speaks of this quantity of *algæ*, etc., and here is one thing I should like to call your attention to (reading) :—

There are special difficulties attending the filtration of water in a climate subject to extremes of temperature. In the winter, the water on the filtering-beds freezes, and thick bodies of ice often form, which require to be removed at a considerable cost when cleaning or repair of the filtering surfaces is needed.

In the summer the hot sun acts upon the sand-beds through a shallow

stratum of water, heating the water, and thus rendering it possible for plants to grow upon the surface of the filters. This growth seriously interferes with the action of the filters, and necessitates frequent cleaning.

Both of these troubles may be obviated by covering the beds by arches or roofs, and it is probable that the growth of *algæ* in the filtered water may be prevented by covering the clear-water reservoir.

No estimate has been made of the cost of covering the reservoirs, but an approximate estimate, amounting to \$80,000, has been made of the cost of building substantial sheds over the filters.

You see it would increase that up to \$500,000 for ten million of gallons daily.

There is another matter I wanted to speak about in connection with this *algæ*, to show you that there is no pond, however pure it may be, that is not liable to have *algæ* in it, although it may not be an injurious kind. Mr. Brackett, one of my assistants, was at Centre Harbor, and wrote me from there on August 5, 1881:—

The water here is full of what I take to be an *algæ*, although it differs from those which we have had. The lake here is about as bad as was the Mystic two years ago. They do not have any thermometers here, but I judge that it is about 99° in the shade here to-day.

I telegraphed him to send me a sample of the water, which he did, and it was worse than any water I ever saw here. The entire surface of the lake for miles was covered with this green *algæ*, but by the time my telegram reached him there had been a high wind, which dissipated them to some extent.

Mr. GREENOUGH.—There is a great deal of talk about the different sources of supply to which we might possibly turn. Do you know of any source of supply in the vicinity of Boston from which we could get any better water than we do now?

Mr. WIGHTMAN.—No, I do not. Of course there are sources of supply which might be better, but the cost would entirely preclude the city's getting them. The reports made by Mr. Davis at the time the Sudbury-river scheme was being considered show that he considered every source of supply within a reasonable distance of Boston, and, with most of them, even if the quality was particularly good, the expense of getting them was entirely beyond the limits to which the city could afford to go. While it is all very well for people to talk that the city can afford to pay any amount for water, if the people were taxed six per cent. on the cost for the works for water brought from a long distance, I think they would change their opinions, and would rather get along with a poorer supply than pay the bills. For instance, I testified before the Committee on Water, that to bring water from Lake Winnipiseogee would cost fifty millions of dollars. You see that, under the act, which requires the income from the water works to pay the water debt, the cost would be so high that it would debar people from using it for manufacturing purposes,—I mean, supposing always it could be done.

There is only one more thing I wanted to say, and that is in regard to this bad taste in the water. It certainly is not attributable to the Sudbury-river water. It is liable to occur in any water. I refer to the cucumber taste. I do not believe the *algæ* have any-

thing more to do with it than anything else. It is caused by the sponge, and it is liable to appear in any water supply, even the purest.

STATEMENT OF TIMOTHY T. SAWYER, OF THE BOSTON WATER BOARD.

Mr. SAWYER.—Something has been said, Mr. Chairman, at these meetings, in relation to the removal of the loam, and a disagreement between the Water Board and Mr. Davis; and then, again, as to how much soil has been removed; and I should like to make a little statement in relation to that.

As has been stated here, our relations with Mr. Davis were always of the most pleasant character. We had the utmost confidence in him, and always adopted his recommendations. We made some changes in his plan; for instance, he did not originally contemplate a brick conduit from the Beacon-street tunnel to the Chestnut-Hill gate-house, and the plan was changed from a wrought-iron pipe to a brick conduit. But all his recommendations, as Mr. Cutler has stated, were adopted by the Board, and we never disagreed with him.

In regard to the removal of the loam, Mr. Davis, in his report, speaks of the advisability of removing it, if possible. So far as the action of the Board was concerned, on the 6th of July, 1878, it was voted

That the engineer be requested to give the Park Commissioners such information as they may require as to the amount of filling that may be obtained from the basins.

Mr. Dalton, Chairman of the Park Commissioners, came before the Board and we had a conversation with him. While I was on the Board this was the only action taken in relation to the removal of the loam from the basins. But the recommendations of Mr. Davis were always adopted, and we never had any disagreement in relation to it.

Now, in regard to the matter of loam, I wish to call attention to this: It has been stated that Prof. Remsen said the filth in Basin 3 encouraged the growth of the *spongilla*. But he says, in his report:—

The materials usually found at the bottom of such ponds, such as loam, etc., do not emit strong odors or give any characteristic taste to the water.

Then he says further, — and I suppose it is the reason why he has been quoted, — he is speaking of the mud from the basins:—

While this mud is not directly responsible for the "cucumber taste," it may possibly have something to do with it indirectly, as it may be favorable to the growth of the sponge, which is, in all probability, responsible for the objectionable condition of the water.

But he adds: —

I am, however, not able to speak with any confidence on this point.

This is one thing I want to have corrected, because he did not give a decided opinion. I have been making a study of the trouble with the water supply here, and will call the attention of the Commission to the result of my investigations. I have taken the pains to look over the record from the beginning of the Cochituate supply.

In the first place I would like to add to what I said in regard to clearing the mud from the basins, that I do not want the Commission to get the impression that nothing has been done to clear out this mud from the basins. There was a good deal done. I have a memorandum of contracts where we paid seventeen or eighteen thousand dollars for clearing out mud in the shallow places, and the places can be given. It is all a matter of figures, and appears in Mr. Fteley's report, where the mud was excavated when the basins were constructed. For instance, we had a contract with an Italian for excavating near Whiting and Bullard's, \$2,000; another for excavating on reservoir No. 1, for \$2,836; another for filling and grading land of Nevins, \$6,704; another for a wooden dam, to prevent exposure of shallow places in Basin 2, \$1,267; another for cleaning up wood and brush in Basins 1, 2, and 3, \$2,750.

I mention this merely to show that something was done.

But what I wanted to call your attention to was this, which may be of service to the Commission. Looking over the reports I find in the report for the year 1851, the engineer, Mr. Chesbrough, said:—

Last spring, principally in the months of April and May, there was a very general complaint of the water tasting badly; and in many instances, though not so generally, the smell was considered bad. The subject received immediate attention, and everything was done that was thought judicious to discover and remedy the evil. The principal measure that was resorted to was a thorough flushing of the pipes all over the city, by passing through them as rapid a current as it was possible to produce by opening hydrants and waste-cocks. In some cases the evil complained of was not removed. In almost every case the trouble was traced to filters that had become filled with decayed animal matter. The probability is that one great cause of complaint in the spring is owing to the change of temperature of the water, causing it to have a flatter taste.

Then, in the report of Mr. Chesbrough for the year 1852, he says:—

Last spring the aqueduct received a thorough cleansing. A peculiar substance like very fine dark mud is deposited upon the surface of the brick-work, and adheres for a time; but, in consequence of the changes in the depth and velocity of the current through the aqueduct, this substance sometimes comes off in sufficient quantities to give the water the appearance of being filled with sawdust. This makes it necessary to cleanse the aqueduct partially twice every year.

Last spring a number of bunches of extremely attenuated and delicate roots were discovered hanging from the top and sides of the aqueduct, between the Newton and Brookline tunnels. In some instances they were three or four feet long, and so tender as to break with the slightest force, and, of course, very easy to remove.

In the autumn a great many patches, in some cases larger than the crown of a man's hat, of a vegetable substance *like sponge* in texture and color, and frequently with coral-shaped branches several inches in length, were discov-

ered in the first mile of the aqueduct, being most numerous near the lake. They were very tender, and easy to remove.

Now, here is another remark he makes in this connection :—

It is a little singular that this should be the first instance of discovering them in the aqueduct, as precisely the same species of plants, apparently, was discovered in the large stopcocks that were taken out of Tremont street, at the head of Dover street, to be repaired, more than a year ago.

That carries it back as far as 1851. Then, in the report for the year 1853, is this remark :—

A very recent examination of the aqueduct shows that the deposit mentioned in the last annual report has again taken place, and must be removed within a short time. The peculiar vegetable substance occurring in patches of from one inch to one foot in diameter, and first discovered in the aqueduct last year, when it was confined to the mile nearest the lake, is now found in every part of the aqueduct from the lake to Brookline reservoir. It is so tender, however, that the ordinary cleansing is sufficient to remove it. There is reason to believe that it grows very luxuriant in still water, as will be mentioned under the head of iron pipes.

Then the Commissioners say this in relation to it :—

The vegetable substance, which is mentioned in the City Engineer's report as having made its appearance lately in the aqueduct, is stated by botanists to be a species of *spongilla*, or fresh-water sponge. There is probably no way of preventing its growth; it is, however, easily removed. The only injury it is known to do is the clogging up of the screens at the reservoirs, and on this account it has become quite troublesome.

Now, here is another thing. In the report for the year 1854 the Commissioners say :—

While, however, the Water Board would congratulate the city on the sufficiency of the supply, etc., they regret to be obliged to report upon a deterioration of the quality of the water, which has recently been most unexpectedly found to be so universally prevalent as to be not only a source of much annoyance to every water-taker, but also of solicitude to all who feel an interest in the welfare of the city. It was first observed in October last, and consisted of a marked and peculiar taste, resembling, in the opinion of some, that of *fish*; but we believe in that of a great majority of persons that of *cucumbers*, or some similar vegetable, the taste being accompanied sometimes by a disagreeable smell.

Adjourned to Tuesday, October 31st, at 4 P.M.

FOURTH HEARING.

TUESDAY, Oct. 31, 1882.

The Commission met at 4 P.M. All present.

STATEMENT OF TIMOTHY T. SAWYER.—*Continued.*

Mr. SAWYER.—I thought, at your meeting the other afternoon, that it might be interesting to this Commission to hear read some notes I had made in looking over the reports of the Cochituate

and Boston Water Boards, in relation to the quality of the water and what had happened in times past. That was my principal object in coming before the Commission, and I have nothing else to offer at this time. It seemed to me that it was important for me, as connected with the Boston Water Board, to be posted a little in relation to what happened in times past, and what was the action in former years in regard to troubles of this kind. Therefore I read over very carefully all the reports of the Cochituate and Boston Water Boards, and made some notes relating to this subject. It is to those notes that I wish to call the attention of this Commission, thinking it might be of service to them in the investigation which they are now making.

I see that some gentlemen are here to-day who were not here at the last meeting. Some questions had been asked as to what had been done by the Water Board toward the removal of the loam, and, fearing that there might be a wrong impression in that respect, I stated to the gentlemen present at the last meeting that we had made some contracts, and that a great deal of soil had been removed. I believe I gave it in figures. All those will appear in a history of the Boston Water Works, which is now being prepared and is nearly ready, and which will be in the hands of the Commission so that they can see for themselves. But I stated that somewhere about fifteen or sixteen thousand dollars had been expended in the removal of the soil from the bottoms of the three basins, and I stated where it was done. I do not know as it is worth while to repeat that. I made the statement because there seemed to be an impression that nothing had been done; whereas, we can show the places where it has been done.

I find in the report of January, 1852, which is the report of the Cochituate Water Board for the previous year, 1851, the following statement in the report of the engineer, Mr. Chesbrough: —

Last spring, principally in the months of April and May, there was a very general complaint of the water tasting badly; and, in many instances, though not so generally, the source was considered bad. The subject received immediate attention, and everything was done that was thought judicious to discover and remedy the evil. The principal measure that was resorted to was a thorough flushing of the pipes all over the city, by passing through them as rapid a current as it was possible to produce by opening hydrants and waste-cocks. In some cases the evil complained of was not removed. In almost every case the trouble was traced to filters that had become filled with decayed animal matter. The probability is, that one great cause of complaint in the spring is owing to the change of temperature of the water, causing it to have a flatter taste. During the winter the temperature of the water in the pipes is seldom more than four or five degrees above the freezing-point, and the change which takes place in this respect in the spring is very great. Lest, however, the difficulty should be owing to collections of offensive matter in the winter, it is intended to commence the general flushing or blowing off this year, the last of March instead of the last of April, as heretofore. Unless dead ends are blown off about once in about ten days throughout the year, complaints of bad water are made. The Brookline gate-house strainers got out of order in the spring and small fish got into the service-pipes and died. Repairs of the strainers remedied this trouble.

Then, in January, 1853, which was the report for 1852, I find this: —

Every ordinary and some extraordinary efforts were made in the spring to prevent the usual complaints of bad water, and with satisfactory success. No complaints whatever were made except in one or two instances, clearly owing to fish in pipes. The screen at the Brookline reservoir is now perfect enough to prevent this.

Then, in the report for the year 1852, Mr. Chesbrough says:—

Last spring the aqueduct received a thorough cleansing. A peculiar substance like very fine dark mud is deposited upon the surface of the brick-work, and adheres for a time, but, in consequence of the changes in the depth or velocity of the current through the aqueduct, this substance sometimes comes off in sufficient quantities to give the water the appearance of being filled with sawdust. This makes it necessary to cleanse the aqueduct partially twice a year.

Last spring a number of bunches of extremely attenuated and delicate roots were discovered hanging from the top and sides of the aqueduct, between the Newton and Brookline tunnels. In some instances they were three or four feet long, but so tender as to break with the slightest force, and, of course, very easy to remove. In the autumn a great many patches, in some cases larger than the crown of a man's hat, of a vegetable substance like sponge in texture and color, and frequently with coral-shaped branches several inches in length, were discovered in the first mile of the aqueduct, being most numerous near the lake. They were very tender and easy to remove. It is a little singular that this should be the first instance of discovering them in the aqueduct, as precisely the same species was discovered in the large stop-cocks that were taken out of Tremont street, at the head of Dover street, to be repaired, more than a year ago.

Then, in the report of 1854, for the year 1853, I find this:—

A very recent examination of the aqueduct shows that the deposits mentioned in the last annual report have again taken place, and must be removed within a short time. The peculiar vegetable substance, occurring in patches of from one inch to one foot in diameter, and first discovered in the aqueduct last year, when it was confined to the mile nearest the lake, is now found in every part of the aqueduct, from the lake to Brookline reservoir. It is so tender, however, that the ordinary cleansing is sufficient to remove it. There is reason to believe that it grows very luxuriantly in comparatively still water.

That is from the Engineer's report. The Commissioners have the following:—

The vegetable substance, which is mentioned in the engineer's report as having made its appearance lately in the aqueduct, is stated by botanists to be a species of *spongilla*, or fresh-water sponge. There is probably no way of preventing its growth; it is, however, easily removed. The only injury it is known to do is the clogging up of the screens at the reservoirs, and on this account it has become quite troublesome.

That was in 1853. Mr. Chesbrough, at the end of his report, makes the following remark:—

Very few complaints of bad water have been made during the year, although there was no general flushing of the pipes, and much less blowing off at dead ends than usual. The enormous quantity of water passing through the pipes daily, it was thought, was quite sufficient to prevent stagnation, except at the ends of courts.

In the report for the year 1854, the Commissioners say:—

While, however, the Water Board would congratulate the city on the sufficiency of the supply, etc., they regret to be obliged to report upon a deterioration of the quality of the water, which has recently been most unexpectedly found to be so universally prevalent as to be not only a source of much annoy-

ance to every water-taker, but also of solicitude to all who feel an interest in the welfare of the city. It was first observed in October last, and consisted of a marked and peculiar taste, resembling, in the opinion of some, that of fish; but we believe in that of a great majority of persons that of *cucumbers*, or some similar vegetable, the taste being accompanied sometimes by a disagreeable smell.

On the presumption that it was local in its origin, and, in fact, confined to the circulation in the mains and distributing service-pipes, they were all flushed out. This, it was hoped, would be a remedy for the trouble, as it certainly would remove all sources of impurity originating in and confined to the pipes themselves. It was, however, not the case; indeed, in most instances, the impurity seemed to be actually increased by the operation. There were also other anomalies quite difficult to account for. The water in the dead ends was frequently proved to be uninfected; on the other hand, in larger pipes, where the current was continuous and rapid, it was quite offensive. It was also satisfactorily ascertained that the water, after being drawn a few days, lost all its repulsive character and became tasteless. There was in no case any appearance of fish, or any other foreign matter in the water, discharged from the hydrants and stopcocks. It seemed requisite to look beyond the limits of the city for the origin of the difficulty; and, upon examination, it was found that the water in the Brookline reservoir and the lake was affected precisely the same way. An analysis by a scientific chemist was ordered. Dr. C. T. Jackson and Prof. Hosford, of Cambridge, examined the water at different parts of the lake and at different depths, and some parts of the water-shed, and made a careful analysis of the water at the lake, and also in different parts of the city, without any disclosure being made to either of them of the places whence the several specimens of water had been taken. The investigation was conducted and the reports were made independently of each other, and without mutual consultation, and they did not, indeed, see each other's reports until they were printed. Both reports came to the same conclusion, that the impurity complained of is derived from vegetable decomposition existing in the lake itself; that it may be attributed to the unusually long and severe drought of the last summer, and to the subsequent rains acting on the peculiar soil of a part of the lake, and on the whole water-shed, and that complete relief might be anticipated from the natural agency of the approaching cold and rains.

A description of Lake Cochituate is given on page 15 of the report of the Water Board, and they tell how it can be affected. Then they say:—

Round pond, near Haverhill, which supplies the town, examined by the City Engineer, was found to be in the same condition, and Jamaica pond had recently been in the same state. Several wells near the lake, and in other places, have had their water affected in the same way, and the water in Chicopee river was, for a time, quite offensive. The Superintendent of the Albany Water Works reported similar trouble in Rensselaer lake, whence their supply was derived in 1853. In October of that year complaints of a nauseous, fishy taste were made, and supposed to be occasioned by a small fish lodged in the supply pipes. The evil soon became universal, and it was obvious that the cause instead of being local was general. In some places the taste was accompanied by a peculiar smell, which was very offensive. The taste affected individuals very differently. Some thought it fishy, and to others it had the taste of cucumber so strong that there was nothing else to which it could be compared. A thorough examination was made, and the Superintendent was of opinion that he had traced the cause to grass, which was found growing in great profusion along the margin of the lake. The plant had shed a great quantity of seeds along the margin, and he found the water above it offensive, and when the water lying upon the seed was taken into the mouth he thought it impossible to doubt the origin of the impurity. The taste of the seeds was also highly offensive. The water was unusually high, and covers a luxuriant growth of the before-mentioned grass. On the presumption that this caused the trouble the water was lowered beyond the

reach of the plant, and in a few days was sensibly improved, and in three or four weeks it attained its usual purity.

That is the Albany report. The Cochituate Board say:—

They are not without proof that the same trouble which now exists had been observed in the lake in past years, though at a distant period of time. The chief cause of the impurity they attribute to long drought and hot weather which prevailed during the season, which reduced the quantity of water and exposed a large extent of marsh and peat land connected with the lake and over the water-shed, by which animal and vegetable decomposition must have been greatly promoted, and the products washed into the lake by the rains which began to fall about the time the offensive condition of the water was first perceived. If this cause was absolutely demonstrated as the true one, it would be expedient to stop the flow of the water from the peat meadows, or remove the peat, and thus carry out the plan originally proposed by the Commissioners, who early expressed their fears that the water might be contaminated by it.

I made a note that the expense was probably the reason the peat was not removed. They thought it might be too expensive to remove; and then they say the cause is removed. They say it now demands their serious attention and earnest consideration—that is, the removal of the peat—and will have it. They refer to other causes which have been suggested, such as fish too abundant, supposed to be the cause by some, or too few, as assumed by others; or sickness and disease among the fish. The presence of dead fish or fish-oil in the water, pertinaciously adhered to by some, is discredited entirely by the Board and the chemists employed by them. To the great majority of water-takers the taste appears to be a vegetable one, frequently compared to that of cucumbers; and they have no idea that it proceeds from animal decomposition. Prof. Hosford makes a lengthy report, and winds up with the following paragraph:—

The recent peculiar taste of the Cochituate water is, in the judgment of the undersigned, due chiefly to extracts, more or less volatile, from the decaying minute aquatic organisms, for the most part vegetable, which, during the late prolonged drought, have been produced in extraordinary quantity upon the low meadow, marshes, bog and peat lands, which supply the surface-drainage to Cochituate lake.

Dr. Jackson closes his lengthy report in this way:—

I regret that we have not been able to settle all the interesting questions that have arisen as to origin of the impurity complained of. This much we have done: we have proved that the peculiar taste of the water does not originate in the pipes, but starts at the fountain-head, and that it is not the result of animal putrefaction, but of vegetable fermentation, and that there is nothing deleterious in the water. There is good reason to believe that the unpleasant taste of Cochituate water is rapidly passing away from operations naturally taking place in the lake, and that the water will soon be as good as ever.

Then, in the report for the year 1855, the Commissioners say:—

There has been no complaint of any offensive change in the character of the water during the year similar to that of the previous one. The impurities of that year gradually disappeared, and were not perceived anywhere about the middle of February, leaving their cause and origin in entire obscurity. We still believe the most plausible suggestion was that made by the Water Board, and confirmed by the opinions and able researches of Drs. Hosford and

Jackson, that the remote cause was to be attributed to the long drought and heat of the summer, and the unusually low state of the water in the lake, and was the result of vegetable decomposition. If so, the evil was one we must probably contend with again, and it becomes important that the water should be continually watched during the summer, and the slightest deterioration traced, if possible, to its source. For a short period an impurity similar in character, but not so intense, was clearly distinguishable in the northern division, and at the gate-house. The cause was traced to Whitney's meadow, in the southern division, where it was quite offensive. A passage for the water had been forced over the dam which separates that meadow from the lake. The passage was closed at once, and shortly after the peculiar taste of the water disappeared. Dug pond was not admitted into the lake during the season. Snake brook was allowed to pass over the dam without any ill consequences.

The Water Board regret that their expectations of a speedy termination of the evil were not completely realized. Their own observation, and the information received from different parts of the city, induced them to believe that about the middle of January, or a little sooner, a decided improvement had begun in the water in the city, though it was still offensive, and at some times and places more so than at others. Near the surface of the lake it was then comparatively pure, but at the depth of twenty-five or thirty feet in the northern division, the repulsive taste continued about as manifest as it was previously. In the other divisions it was almost entirely tasteless. It was also discovered that the water of Dug pond, whose purity had never before been suspected, had undergone a similar deterioration, and at a depth of twenty-five feet clearly resembled that of the northern division, while at the surface it had no offensive taste.

The improvement, supposed to have been commenced about the middle of January, went on increasing until the 1st of February. At that time the water at the lake seemed to have acquired its former purity. Taken from every depth in the northern division it was entirely tasteless. In most places where the deterioration was marked and decided, there is now (February) no appearance of it.

The Engineer says:—

But very few of the peculiar vegetable substances heretofore mentioned were found in the conduit.

The conduit was examined in December, 1855, by the City Engineer and Mr. Knowlton. But very few of the peculiar vegetable substances heretofore mentioned were found in it. On the 28th of January, 1856, holes were cut in the ice in different parts of the lake, and water was drawn from a depth of sixty feet, and from various lesser depths. There was no perceptible difference in the taste, but it all appears pure and sweet.

In their report for 1866 the Board say nothing about the quality of the water. The Engineer says:—

During the entire season the water has been allowed to flow freely over the meadows connected with the lake, and with Snake brook, and it has at all times been perfectly good.

Mr. SHEPARD.—Where is Snake brook?

Mr. FITZGERALD.—It is the nearest brook to the outlet of the lake.

Mr. SAWYER.—(Reading):—

The conduit was thoroughly cleansed in July, between Charles river and Brookline reservoir.

In the report for 1857 the Board say nothing about quality. The Engineer says:—

The quality of the water is now very good, and has been throughout the year, except a few days in the fall, just after some heavy rains, when a slight vegetable taste, similar to what has been observed before, was found in it.

In the report for 1858 the Board say nothing about quality. The Engineer says : —

The water has been of the very best quality throughout the year.

In the report for the year 1859 there is nothing about quality. It appears that there was a break in the conduit about that time. In the report for 1860 nothing is said about quality. In the report for 1861 the Board say : —

The quantity and quality of the water supplied to the citizens have been entirely satisfactory.

In the report for the next year (1862) nothing is said about quality. The interior of the aqueduct had been thoroughly examined and cleansed.

In the report for 1863 the Engineer says : —

The conduit was thoroughly examined in July and was found quite clean, with the exception of a small section between the lake and Station 100, where there was a considerable accumulation of the peculiar vegetable spongy matter referred to in previous reports.

The Board say : —

The aqueduct (interior) has been thoroughly cleansed and examined a number of times by the Board, the City Engineer, and the Superintendent of the Division.

The Engineer says : —

The water has been shut off for examination, cleansing, and repairs ten days in all during the year.

In the report for 1864 the Board say : —

The water in the conduit has been shut off during the year four times, in order that it might be examined, cleansed, and repaired.

In 1866 they began to make their reports in May, and this report is for sixteen months. They are apprehensive of a short supply, and say the aqueduct was emptied twelve times during the year and examined by the Commissioners, the City Engineer, and Superintendent. The Engineer's report says : —

The section from the lake to Dadmun's brook waste-weir was found to be coated with the peculiar vegetable matter alluded to in former reports, and has been thoroughly cleansed by the Superintendent.

Nothing was said about quality.

In 1867, in the report from May, 1866, they say that portions of the conduit were examined several times during the year. There was a great freshet in July, and the level of the lake raised eight inches in twenty-four hours. Nothing is said about quality.

In May, 1868, the Board say that the Brookline reservoir had not been cleaned out for over ten years. An examination of the interior of the conduit was recently made, and it was found to be very dirty and slimy, and should be cleansed before hot weather.

In the report made in May, 1869, the Board say there was an examination of the conduit in one day; the general condition was found to be the same as at the last examination. They say:—

The dirt and slime in the section of the conduit near the lake should be removed at once.

Other portions of the conduit are reported as clean.

In May, 1870, the Engineer says:—

The annual examination of the interior of the conduit was made last month. The condition was much the same as last year. The section from the lake to Dadmun's brook was very dirty, even worse than last year, but since the examination it has been thoroughly cleaned.

In May, 1871, they report that the conduit was examined in April and found to be generally in a clean condition; very little dirt, and most of that in the tunnel.

In May, 1872, they report that there was a drought during the year 1871, and it is referred to by the Board as causing great anxiety. That was the year when Mr. J. P. Davis entered upon his duties. The conduit was not examined at all.

In May, 1873, they report that the conduit was examined on Oct. 12 and 13, 1872, and found to be in good condition; but in the transcript of the record is the following:—

For a long distance (from the gate-house to Dadmun's brook) the bottom is very sandy, and the sides are covered with a substance resembling sponge; there is considerable moss on each side of the conduit, and considerable fungus.

Mr. Stanwood, the Superintendent of the division, in his report, says:—

The section between the gate-house and the waste-weir, at Dadmun's brook, was found to be very foul, being covered with a vegetable growth and a great deal of sand on the bottom, that was carried in by the pumps.

That was the year they pumped, on account of the water being low. (Reading):—

October 25th the water was drawn off and kept off four days, and the section that required to be cleaned was attended to.

In the report of May, 1874, it appears that the conduit was examined November 19 and 20, 1873, and again April 14, 1874.

In the report of May, 1875, there is the statement that there was drought and pumping in 1874 from September to February, 1875. The conduit was examined December 3, 1874, by Wightman and Cunningham. The Superintendent of the Western Division gives with his report a table of all recorded examinations of the aqueduct.

In May, 1876, the report says the conduit was examined July 27, 1875, and there is the following statement:—

Early in October, 1875, complaints began to be made at the office of the Water Board that Cochituate water tasted badly, and was unfit for use. The taste was variously described; some thought it like cucumbers, others like fish-oil, still others like dead leaves; but, as a rule, it was spoken of as a cucumber taste. At first, the complaints came from the South End and

Back Bay; later from the West and North Ends; finally from South and East Boston. Even after the taste became very wide-spread, people living where there was but little circulation in the pipes, as in some parts of Dorchester, reported that the water supplied to them was unusually clear and sweet.

October 23d the lake was visited and samples of water taken at various points and at all depths; but not the slightest trace of the peculiar taste could be discovered. Samples taken where the water was shallow, and some from points near the bottom in deep water, had the earthy taste of pond-water; but the greater portion of them were clear and tasteless.

October 26th the Brookline and Chestnut-Hill reservoirs were visited; but no cucumber taste could be detected in the water contained in them. Water taken in front of the screens of the efflux gate-house at Chestnut Hill was tasteless, but a sample taken from behind them, at the mouth of the outlet pipe, had the cucumber taste in a slight degree.

At that date the taste may be said to have been confined to the water in the pipes, but the next day it was discovered in all parts of the Bradlee basin of Chestnut-Hill reservoir, having spread through that large volume of about 500,000,000 gallons of water in one night, apparently. A thunder shower and violent winds and agitation of the water during the night may have aided in developing the taste. The reservoir was shut off immediately, and in a short time no taste could be detected in the water delivered in the city, indicating that the trouble originated in the reservoir, or, at least, that the conditions necessary to develop the taste existed there.

On the night of December 3d the gate was opened about one foot, and three or four million gallons of water let into the distributing pipes; but the effect was so disagreeable that the gate was closed the following morning. The trouble continued until April 1, when the water was let on to the city, and the reservoir has been in constant use since.

Professor Nichols, of the Institute of Technology; Mr. Edward Burgess, Secretary of the Boston Society of Natural History; Professor Farlow, of Harvard University, made thorough examination of the water during the year, which are all given in the report.

The report of May, 1877, says: —

The water from Cochituate lake during the past year has been of good quality, and no complaints have been heard from any quarter. The unaccountable cucumber taste, which for a while shut out the use of the Bradlee basin of the Chestnut-Hill reservoir, to which it was confined, has unaccountably disappeared, and since the gate was opened, on the 1st of April, 1876, the basin has been in use, and the quality of the water unexceptionable. The mingling of the Sudbury with that of the Cochituate water has had no unfavorable effect on its quality, and there is every reason to believe that the quality of the Sudbury-river water, when the works are completed, will be perfectly satisfactory.

That brings us up to the time of the Boston Water Board.

Now, I have here the report of Professor Nichols, who made weekly examinations; but I will read on from my memorandum: —

The conduit was examined (says the report of May, 1878) but once, May 8, 1877. A certain amount of brushing and cleaning was done. No complaint of the quality of the water was made.

In the report of May, 1879, there is an interesting statement of Professor Ripley Nichols, giving the results of his analysis of the water supplied by the Cochituate works. As in previous years there is some variation from time to time in the quality of Boston water; but he concludes his paragraph on this subject with this remark: —

We have every reason to congratulate ourselves upon the character of our water supply.

The Engineer says the yearly examination of the conduit was made June 11, and no noticeable change since the previous examination was found.

I do not know but that covers the whole ground. Professor Nichols made these examinations. His reports are included in the annual reports of the Boston Water Board, and they speak for themselves.

But after this trouble with the Chestnut-Hill reservoir, we had frequent consultations with Mr. Davis, and Professor Nichols was employed at the time, and he was making weekly examinations of the water, the results of which are all here. The result of those examinations was that he said there was nothing objectionable in the water, and we had reason to congratulate ourselves upon the character of our water supply. Those results are all recorded in the reports of the Boston Water Board, and they speak for themselves. But the question is often asked, What have the Boston Water Board been doing about this trouble? They were in with the most eminent professors, chemists, and engineers, getting advice and information from them. Professor Nichols was making weekly examinations, and doing what it was impossible for the members of the Water Board to do themselves.

I have some memoranda here. In the report of 1879 the Engineer says: —

The yearly examination of the conduit was made June 11, 1878, and no noticeable change since the previous examination was found.

The examination of a part of the conduit was made by F. O. Stearns, who says in his report: —

Some workmen were scraping the sides over the gate-house. I noticed after passing them that the vegetable growth had increased, and that it extended, although diminishing, nearly a mile from the gate-house.

Mr. Stearns' examination was from Lake Cochituate to Dadmun's brook.

I have a memorandum here that Reservoir No. 3 was filled for the first time in December, 1878.

In the report of May, 1880, the Engineer says: —

The quality of Cochituate water has been good throughout the year. The Sudbury has been somewhat colored, and at times has a slightly bitter taste, which was noticed in the city late in the fall, when the river-water was sent directly into the distributing pipes without passing through Chestnut-Hill reservoir. The rest of the time Cochituate and Sudbury were mixed.

In the early part of September an abundant growth of *algæ* developed itself in Reservoir No. 3. It was immediately isolated from the rest of the supply, and owing, probably, to that precaution the *algæ* did not show themselves, except in small quantities, in Basin No 1, Farm pond, and Chestnut-Hill reservoir. The presence of *algæ* in Basin No. 3 was observed until the beginning of December, when the water, having resumed its former quality, it was drawn as usual for the supply of the city. These microscopic *algæ* were of two kinds, one having a somewhat globular form, the other presenting the appearance of a curved string of beads. The cause of their growth is not known, and no known remedy can be applied. The formation of *algæ* seems to be wholly independent of the depth of the water, but closely

follows the change of temperature, increasing when it rises, and diminishing when it lowers.

There were no *algæ* in Basin No. 2. The clathrocystis (*algæ*), another kind, appeared in Horn pond in large quantities in July, and found its way into the Mystic and the distributing pipes. It could not be stopped with screens.

Then Mr. Davis made a report upon filtration, and Professor Nichols another on *algæ*. Then the Superintendent discovered fish dying in Chestnut-Hill reservoir, and that was referred to Professor Nichols, who gave as a cause a vegetable parasite attaching itself to the skin of fish, and feeding on their bodies. This disappeared in a few weeks.

In May, 1881, the *algæ* were reported to have appeared in basins Nos. 1 and 3, and the cucumber taste in Lake Cochituate, which is so recent that you all know about it.

I thought it certainly would be useful to me, and that it might be well for the Commission to know what had been the history of the trouble with the water. I think that if you read the reports you will find that from the very beginning, or within a very short time, they began to complain of the water. In some seasons it has been very marked.

I do not know how far the Commission want to go over this ground, and I don't know but they have already been over it. It has required some little labor to go over what I have done; but it is an interesting account of the trouble with the Cochituate water long before the Sudbury-river supply was thought of or used; and there seems to be some similarity in the experience with both supplies.

Dr. BLAKE.—All the reports seem to point to the same causes of this cucumber taste, and all seem to depend upon the presence of the *spongilla*,—although it was not always recognized as being present.

Mr. SAWYER.—I do not know how far it might be attributed to that cause. They seem to have spent some time upon it, and mention it as being found.

Dr. BLAKE.—But they do not seem to connect the smell of the sponge with the cucumber taste; whereas Prof. Remsen does make such a connection.

Mr. SAWYER.—Yes. As will be observed, there was a time when the question with the Cochituate Water Board was, whether they did not make a mistake in not removing the peat from the shallow places in Lake Cochituate. They did not consider it absolutely essential, and it was not removed. But afterwards, when they raised the question again, the water became all right, and then they thought it was not worth while to remove it.

Dr. BLAKE.—But that seemed to connect the lowering of the water, and the consequent exposure of these wide margins and flats, with the disagreeable taste of the water.

Mr. SAWYER.—Yes, sir. I have made these notes and read them without any opinion; but merely to get at the facts. There is one thing more. When I was on the Board before, if anything came along that was interesting I used to pick it up and put it

away for future reference. Among other things I came across this document on the New York water supply. What I want to call attention to is this: it has been mentioned here, and the impression was left, that the Croton water was better than ours, and that no fault had been found with it. Now, I thought I would take the following extracts from the editorials of five leading New York papers, in regard to the threatened calamity from this source. This was in 1876. The title of the pamphlet is "New York Water Supply," and was published in 1876. (Reading) :—

OUR FILTHY AND DISGUSTING CROTON.—Our people are, perhaps, not fully aware that they are daily pouring down their throats water absolutely reeking with filth of the most disgusting quality. In a show window at the corner of Broadway and Seventeenth street there are now on exhibition two jars of water,—one containing a yellowish, dirty liquid, somewhat like kerosene. That is our Croton, from the regular supply-pipe. It would be amusing, if it were not so serious a matter, to witness the astonishment depicted on the countenances of the people that congregate there, contemplating the serious effect on their health and that of their children, as it occurs to them that this liquid is their daily drink. Something must be done, and that quickly, or the health of more than a million of people will be imperilled.

Many private families and hotels are resorting to other sources for water for table use.

Through the Croton valley are stables, slaughter-houses, and privies, drained into the water that New Yorkers must drink.

An examination of the Croton shed showed a general destitution of water prevailing in the whole section. Croton lake is a reservoir of filth, and the storage-reservoirs a repository of farm filth.

MALARIA IN CROTON WATER.—Dr. Lente, a distinguished physician of Cold Spring, Putnam Co., attributes the malaria in this city to the drawing down of the reservoirs and lakes in this country to supply the Croton. The general effect of the present system is to expose thousands of acres of land previously under water to the air, rotting and parching in the sun, then steeped in rain-water with the first shower, which, when thus polluted, finds its way to the city conduits.

THE CROTON CESSPOOL SYSTEM.—Is it possible that the engineers of the Croton aqueduct cannot devise a remedy for the fearful evils that surround us, arising from an impure supply of water to this city? Have we reached the limit of an engineering skill in this respect, and is the condition of the Croton water to grow from bad to worse? These are questions which every intelligent citizen of New York is asking just now, in view of the formidable dangers to the public health, which the horrible condition of Croton water creates.

THE FOUL CROTON WATER.—The truth is that our water system is being botched, and no amount of scientific twaddle can conceal the fact. Water that is charged with objectionable animal matter, the drainage of farm lands and swampy grounds; and, in fact, made the medium of conveying away the refuse of a thickly settled region, cannot be filtered by "contact" with the great motionless mass of water at the dam; neither will the bright idea of cleaning the park reservoirs help matters. The supply is poisoned at its source.

THE CROTON SHAM.—The whole Croton system is a sham and a delusion no longer endurable. It is a fraud on the people to spend another dollar to perpetuate it. Better go to Lake Ontario at once if necessary,—no matter what the cost,—rather than suffer the losses and discomforts entailed on this great city through this great deception. It is notorious that for the last five years there has not been a dwelling-house in the higher districts that has had a flow of water above the second story, and much of this time manufacturers and others have been scrimped, and often compelled to suspend business altogether, because of the meagre supply. This condition of things began in 1868, and has been growing worse ever since, until it is no longer bearable. For the hundredth time we are now told again by the officials not to be alarmed,

that there is an abundance of water lying around loose up in Putnam and Dutchess counties, and it only needs plenty of new ponds to give us a bountiful supply. We don't believe it. We were told the same thing repeatedly when the new Boyd's reservoir was under construction, and, if possibly that failed to meet the demands in time of great drought, then drawing down the lakes was certain to supply the deficiency. Boyd's reservoir has been finished and filled, and the last drop drawn out of it. The lakes have been drawn from to an extent never intended, threatening the health of the entire section, and arousing the indignation of Putnam county residents; and still we are suffering from thirst and famine in the city never before experienced. Away with any more promises of reliance from that section; but let us demand that those whose business it is shall look, without a day's delay, to some other source of water supply for this famishing population, which will guarantee an abundance of pure quality now and for all time.

I read these not for the purpose of having any effect upon this investigation as regards our water supply, because it seems to me that it is very important that what this Commission was appointed for should be attended to; but I read them to show that they have had the same state of things in New York that we have had here.

STATEMENT OF SAMUEL H. DURGIN, M.D., CHAIRMAN OF THE BOARD OF HEALTH OF BOSTON.

The CHAIRMAN. — Dr. Durgin, the Commission would be pleased to hear what your opinion is in regard to the water, and what the cause of the impurity is, whether you consider it bad for the health of our citizens, and whatever remarks you would like to make.

Dr. DURGIN. — I do not know particularly why I am summoned before the Commission, except from the position I hold, and from the fact that for the last two years in the reports of the Board of Health I have taken occasion to reflect what seemed to me to be the popular feeling in regard to the water supply. I do not come here to-day of my own accord. I came because you have summoned me, and I am not here to attack or defend anybody whatever.

For the last two years it has come under my observation and notice that there has been quite a considerable dissatisfaction among the inhabitants of Boston in regard to our water supply, and it has come under my own notice that the taste and appearance and the smell of the water we have used were not pleasing. From some examinations which have occurred to me, it has seemed that the water was not of the character that it ought to be. Whether it was all that we could reasonably expect under the circumstances is something that I am not prepared to say. I do not know that I have anything to say further than I have said in the last two reports, and which, as I said before, reflect that feeling which I have gathered from those who have complained of the water to us, and as I have gathered from the expressions outside of the Board of Health office.

There have been a great many complaints from different classes of persons in Boston for the last two years. I have always referred people to the Water Board and the City Engineer, the parties who were entrusted with the care of the water supply. In one in-

stance I had a specimen of the water taken and given to Professor Wood to examine, with the result which has been recorded in the Board of Health reports, expressing the fact that there was an excessive amount of vegetable matter in the water, although not, in the opinion of Dr. Wood, to a dangerous extent. Last fall, owing to some investigations that the Board were pursuing, we went up to the source of the water supply at Sudbury river, and saw the basins and Lake Cochituate. We found Farm pond containing water in every appearance like that which we are getting at our faucets — colored, and having the same cucumber taste such as we got in the city. We also found that same taste in Chestnut-Hill reservoir, but I think not elsewhere. In Basin No. 2, which is the upper basin on the Sudbury river, the water was in a fair condition, somewhat colored. In Basin No. 1 the water smelled very badly; it was bad in Basin No. 3 the same. Lake Cochituate and Brookline reservoir seemed to be in good condition, except at the northerly end of the lake, where there was a portion of the dam off, which was in a very filthy state indeed, receiving the drainage from a portion of Natick. That water was being filtered through a dyke of sand or gravel into Lake Cochituate. Although the water below it did not contain the filtering particles that the water above it did, the taste and condition were not so very different. This was to me a disgusting appearance.

I would say, in behalf of those who complained to the Board of Health, that, if it is possible to improve the water, it seems to me that it is due to the citizens to have it done. I should say, as a citizen of Boston, that I am not pleased with the taste, the appearance, or the smell of the water to-day.

Mr. GREENOUGH. — What do you mean by to-day, doctor?

A. The most of the time for the last two years, and I should say that even to-day it does not seem to me, from my own unaided senses, that the water is quite as good as it ought to be.

Mr. GREENOUGH. — You said the water was analyzed by Prof. Wood, and he thought there was too much vegetable matter in it, although not enough in his judgment to be dangerous. Is that what I understand?

A. Yes, sir.

Q. What danger would you expect from an excess of vegetable matter?

A. I should expect, in a certain class of persons, it might unfavorably affect the digestive organs.

Q. In what class of persons?

A. The weak and sickly class.

Q. Would the fact that it did so be brought under your attention as chairman of the Board of Health, in any way?

A. I do not know that it would specially. We do not get sick reports, we get death reports. If there was a certain disease prevailing which might be attributable to some special cause, it would come under our notice directly or indirectly, and would be likely to set an investigation on foot. But the matter of saying that a certain person has been made sick by drinking Cochituate water is not easy of demonstration. There are many causes of

disease, we might say, which we believed to be such, but yet are not susceptible of the easiest demonstration. I do not know that I have been mindful of any special case of disease brought about by drinking this water. Neither do I believe it is necessary that we should have found some person ill or dying, as a direct result of drinking this water, in order to say that the water is not good or healthy to use.

Q. So far as the vegetable matter goes you think it would, probably, unfavorably affect the digestion, although no special case has been brought to your notice as chairman of the Board of Health?

A. That is the proper statement.

Q. Now, if the water had an excess of sewage in it, the tendency would be toward typhoid fever, would it not?

A. I do not know as I am able to say it would produce typhoid fever. It might produce other diseases.

Q. But, so far as excess of sewage, chemical analysis does not show that? Although the water coming into Pegan brook is very filthy, the general effect upon the water supply is not perceptible?

A. I do not know that the effect of Pegan brook upon our water supply here in the city has been demonstrated at all. Neither would I regard it necessary to demonstrate at this end of the pipe that there is an element of sewage at Natick, in order to say that that is wrong and should be remedied.

Q. Now, as chairman of the Board of Health, you must be cognizant of laws affecting the pollution of water supplies, are you not? Or, does not that case come under your jurisdiction?

A. I do not know the special application of your question.

Q. I want to know whether you are familiar with the laws which govern the pollution of water supplies in this State?

A. No, sir; not specially familiar with them, having nothing to lead me to study them specially. We have not the slightest thing to do with the water supply.

Q. Not with the enforcement of the laws?

A. No, sir.

Dr. BLAKE.—Not specially, but professionally, you are familiar with the general causes of pollution?

A. In a general way.

Q. And in connection with the water supply have you formed any opinion as to the causes of the dangers which exist?

A. I have gathered some general notions in regard to it. They are not what those of chemists, and men who have given special study in that direction, would be,—not by any means.

Q. Well, as a physician in charge of what we may call the sanitation of the city, you have given more than an average physician's attention to the causes of disease? Now, looking at it from that point, and from your knowledge of the diseases prevalent in the city, do you think the presence of a large amount of vegetable matter in any way contributes towards the sickness of our community?

A. I should not have the slightest doubt of it in the world.

Q. That is, you have no doubt that a certain class of idiosyn-

crasies are affected by water which would not be dangerous to the great mass of people?

A. That is a fact.

Q. So that without being able to come to it directly, still you, as a physician, recognize its effect upon certain classes, while it would not affect the entire community?

A. The effect of a change of water, or, perhaps, a storm, might have a general influence upon the community, that would be general, not special. The lightning may strike, and you can see just who it hit, and say the lightning did that mischief. But, in the water supply, you may have a degree of pollution which you may say, in a general way, debilitates. It does not do the work of pure water for the human economy; but you cannot say, perhaps, that that child or that woman, or that man, died because he drank that water. You may be able to say that that person was unfavorably influenced by drinking water which was not of a good quality.

Q. Diarrhoea or imperfect digestion might be the result of drinking water, which, to a robust person, might not be dangerous?

A. Certainly.

Q. And you have had instances of such cases brought to your notice?

A. Yes, sir. It is within a few days I have heard a very honorable physician of our society say that he, himself, was very unfavorably affected — speaking in the most confident, positive way — by drinking the Cochituate water, — a man who has been very highly honored in this State and by his profession.

Q. In the analysis made by the Board of Health of the water, what has been the result as to the amount of solid matters found in the water, — what percentage?

A. I have them not. It is in the report of the Board of Health of 1881, with remarks. The remarks were brief, and by Professor Wood, and to the effect that there was an excess of vegetable substances. I should say, perhaps, only in guessing at it, that there was double the amount of vegetable substances that there should be.

Q. Have you any account of the methods of purifying water; have you any suggestions of a remedial character to make?

A. I have thought that if we are to continue our water supply by means of rivers and storage-basins, those basins should, in the first place, be deprived of the vegetable substances and loam which we know are very likely to give rise to the growth and decay of an excess of vegetable matter, which is almost necessarily the case where there is a rise and fall of the water, and that they should be properly prepared; that they should have a uniform depth, if possible, and that they should be deprived of vegetable substances.

Mr. SHEPARD. — You say if we are to continue that means of supply? Do you know any other means of supply that Boston can get?

A. There is sometimes a doubt expressed in the minds of some people as to the desirability of getting a water supply by means of rivers and lakes, they being so constantly subjected to lowering

and raising, and needful cleaning, which always means mischief. You cannot drain off a lake or pond or basin without killing off all the live animals and exposing surfaces to a condition of air which is uncommon to it, and thereby giving rise to a vegetable growth which must die after the basin is filled again; and therefore, after a time, get impure water from the death of the animal organisms, and from the death of grasses and other vegetable growth. In view of all these liabilities it has sometimes seemed to me as if it would be a better plan to take the water from the surface by excavations, so that the water as given to the people should be filtered so as to be of uniform temperature, and be clear of objectionable particles, and have that advantage which water gets by being filtered through deep soils. I do not know whether any such advantage is to be gained about Boston.

Mr. GREENOUGH.—Do you mean in the shape of artesian wells?

A. No, sir; but excavations in places where a proper supply could be gained, and pumped to a sufficient elevation to supply the city. This is only, perhaps, speculative, and I did not intend to mention it.

Mr. SHEPARD.—I only asked about it because you said, "If we continue our present supply," and I thought perhaps it might have occurred to you. I should like to ask if you know of any community which is supplied in that way?

A. I cannot give you the exact fact, but my impression is that in some parts of Germany this same plan has been adopted. I have not pursued this sufficiently to give you all that I could wish in this line, not expecting to be called upon at all, and it not being in my direct line of duty; but I think you will be able to get at those gentlemen who have had opportunities for travel and study which have put them in possession of these facts. Of course you all know that there are difficulties which are almost entirely insurmountable in keeping up uniform purity in the waters in rivers and basins and lakes. There are many difficulties in the way. If we continue the present method, those difficulties should be reduced to a minimum, at whatever cost. The community should be made to feel that every means that is possible has been adopted to give us a uniform and pure water to drink.

Mr. DESMOND FITZGERALD.—If it be allowable I should like to ask the doctor one question. I admire the spirit in which the doctor has pursued the investigation, and I only wish all had manifested the same feeling. You say the basin drawn down necessarily exposes flats which produce a deleterious quality of water. I want to ask you if you mean by that a pond which is already formed with natural borders of gravelly soil—whether the water in that lake is made deleterious by exposure, or whether you simply wish to confine it to a new structure?

Dr. DURGIN.—If you have a natural lake for the supply of water, and at one season of the year that lake is several feet lower, with sloping borders, and vegetation forms there at times, and then is filled again, I understand that the vegetation which springs up at a low depth of the water, or on exposure, will die after the

water rises again and be capable of exhaling and affecting the water of the lake.

Q. Is that founded on a particular theory, or facts, or observation?

A. That is only my belief in a general way.

Dr. BLAKE. — It seems to me, in reply to Mr. Fitzgerald, that among the extracts read by a member of the Water Board here, the same remark was made in relation to Lake Cochituate, which is a natural pond of water; and when the water was drawn down five feet in depth, the exposure of the margin was supposed to result in exactly that change of the water.

Mr. FITZGERALD. — I should like to have a word to say later about that, if I may be allowed; but still I do not wish to interfere at all.

Dr. BLAKE. — Certainly.

The CHAIRMAN. — If Dr. Durgin has nothing more to suggest, we will hear what Mr. Fitzgerald has to say.

STATEMENT OF DESMOND FITZGERALD. — *Continued.*

Mr. FITZGERALD. — I do not wish to take up the time to discuss any theories, if it is too late. But there are one or two points I should like to speak about, if allowed, without going into the subject fully. There have been so many statements thrown out in the public prints, and in a great many different ways, in regard to the management of the Water Works, that I have taken the thing somewhat at heart myself, and from the opportunities I have had for practical observation I thought there were some things I should like to speak about.

And in regard to this drawing down of natural lakes, my observation has been such that it does not exactly coincide with what Dr. Durgin has stated here. I believe myself when a pond or basin is newly filled, and new areas are covered with water, and those are exposed, that the effect upon the water for, perhaps, several years to come, is, perhaps, deleterious. But after the lake or pond is formed, and its borders are formed, the same as Lake Cochituate now is — and Lake Cochituate, you must remember, was raised twice, both times by Act of the Legislature; the first time the natural high-water line was about five or six feet above the flume, and it was raised to eight feet; and then to ten, making certainly five feet, and the result was — and those notes of Mr. Sawyer are exactly what I should look for as a result — that the water was bad for several years; but now the water in the lake certainly is never better than when it is low. If you go all around Lake Cochituate, and take water from certain depths, you will find it is clear, and as fine water as you find anywhere; but the opposite is sometimes the case when the lake is full. So I do not think it follows that when the lake is drawn down the effect upon the water is bad. It seems to me the effect has been often good. Even in Lake Cochituate, which has remarkably fine, sandy borders, there are quantities of plants growing. You may see them stretching from the high-water line to six, eight, or ten feet be-

low. When the water is drawn down in the lake, and we use it as storage-water, those plants die off. I believe it actually results in good to the water, after an artificial pond has become like a natural one.

Now, gentlemen, in almost all these discussions which have occurred, the great question which has agitated the minds of the Water Board and all its officers—and I should prefer to hear the City Engineer speak on this subject rather than myself—has been that of quantity; how to keep this great city, which is growing so fast, supplied with an adequate supply of water. You will realize this when I say, that in 1877 our consumption was only about twenty-one millions of gallons a day. Since that time we have had built this large system of works and put it in running order, and we were delayed a number of years on account of the action of the City Government, the Board not having the funds to proceed, and at the last moment those basins were filled, and the water had to be rushed in immediately to supply the city. Almost every year since that time we have had such periods of drought that the water in the storage-basins had to be used before the period in which it should have been stored had passed.

Now, my own opinion is, that the water will improve rather than deteriorate in quality. The only thing I can hope for is, that the City Government will give us funds enough to complete the whole system of basins on the Sudbury.

Here I may say that when the Sudbury scheme was broached, the most careful examination was made by all the experts who could be summoned on the question. Every source of supply was examined within fifty miles of Boston. Thirteen different schemes were studied, not only in reference to quality but quantity of water, and from every point of view. I believe fully that we have in the Sudbury river the best source of water supply within reach of the city of Boston.

It is impracticable to furnish water in the way Dr. Durgin speaks of, from filtering-galleries. In Brookline they have had difficulty in doing it, and have had to extend their galleries. But the amount of water that can be procured from filtering-galleries under ground is very limited indeed.

Mr. WIGHTMAN.—I made a statement here at the last meeting that there was great complaint about the quality of water, and that there were large quantities of *algæ* in the water. I do not know whether you noticed them, but you know there were complaints about the quality of the water. I have seen the water green myself.

Mr. FITZGERALD.—Yes, sir.

Mr. WIGHTMAN.—I only wanted Mr. Fitzgerald to confirm the statement I made.

Mr. FITZGERALD.—I only want to say, in regard to this question of water supply, that people are apt to go too much into details and overlook the great questions which should really engross attention. I have been fairly astonished at some of the statements published by a gentleman before a scientific society. I may be pardoned for referring to this, because some of the figures he used

were given to him by our department, and he has so misused them as to dishonor his own city. They can be proved to be utterly false; whether so wilfully I do not wish to say, because I do not wish to misjudge a man's motives. But in this article, published in the "Boston Herald" of last Sunday, a paper read before the Medical Society, the statements, so far as the engineering questions are concerned, and as concerns the water supply, are grossly inaccurate. If I only had the time, and if the gentleman were here, I would be glad to expose them fully, because we have the proof in our own hands.

Mr. SHEPARD.—Will the supplementary supply be sufficient for the city when all the basins are completed?

Mr. FITZGERALD.—You have the City Engineer here and I should prefer to have him state. But when the scheme was adopted it was estimated for forty million gallons a day, that is, when you developed the storage capacity itself. Until you do that and allow a little margin, so we shall not be pushed to run water into the city before it should be used, we shall be troubled with this excess of vegetable matter in the basins. I do not think it is proved that the loam is the immediate cause of it. In Basin No. 2 we have as much loam as in the other basins, and we have always had good water there. It is an extremely difficult question, and I do not believe any person who studies the question several months, with the immense quantity of facts on record, will wonder that it is complicated. Yet the question can be cleared of many of these complications and made very simple by keeping the main facts in view.

Mr. GREENOUGH.—Have you any recommendation personally as to the possibility of improving the water?

A. No, sir; but I feel confident that if the City Government were to appropriate sufficient money to develop the whole scheme of the Sudbury river, it is the only practical way of improving your water, except by a scheme of filtration, which will be at a vast expense.

Q. That is to say, to have a large excess of water supply?

A. Sufficient to supply the city when it is needed; and we are very much crowded now. When the water was first introduced into Boston, in 1848, the people generally supposed that they had too large a supply, and that the engineers had been too extravagant. Mr. Bradlee knows all this. But in less than ten years the Water Board had to resort to advertisements in the public prints to warn people to be more careful in the use of water. In 1867 Lake Cochituate was too small to supply the city of Boston, and yet they had to work along until 1871 before anything was done to increase the supply; and, then, the fact must not be lost sight of that those basins were filled in 1878.

Mr. SAWYER.—As early as 1857 the Water Board were calling the attention of citizens to the excessive waste, and telling them that if they did not be more careful they would come to want; and it ran all the way through.

Dr. BLAKE.—I should like to ask Mr. Fitzgerald the question whether he thinks the causes of complaint concerning the water would be remedied if we took away the loam from the basins,—if that is something which ought to be done?

A. Well, sir, I think really the causes of complaint last year were ascertained by Prof. Remsen. I think every fact there shows conclusively that the trouble then was confined to Farm pond and to the causes which he described. When we drew down the water we found it exactly as he said we should. The bad taste was confined to that basin ; but, unfortunately, we were obliged to run all our water through there ; so all our water was polluted at that time. But I believe it was the same with Lake Cochituate, and it was confined to that period, and the water afterwards changed its character. It is something which is liable to come into any source of water supply.

Mr. GREENOUGH.—Take the yellow color and muddy taste to-day,—do you not suppose it is attributable to the loam in the basins?

A. No, sir, and I can tell you why. If you go to the head of Basins Nos. 2 or 3, and take specimens of water there and compare them with the Boston water, you will find them more tinged. The water in Basin No. 2 is undoubtedly improved in the passage through the basin, so far as I can judge ; I am not speaking chemically. But the water at the foot of Basin No. 2 is clearer than where it goes into the basin.

Dr. BLAKE.—Do you not believe that is the cause, and the removal of it would remedy the evil?

Mr. GREENOUGH.—He spoke of the color particularly.

Dr. BLAKE.—He spoke of the color and taste.

A. I was speaking of the color more particularly. In regard to the taste, do you mean the taste at present?

Q. Yes ; if the taste is not the result of the maceration of this vegetable mould, what benefit would result from your long storage after the Sudbury system is developed ? I take it your plan is to allow the water to stand three years, and allow the decomposition to take place ?

A. Of course in the spring you would naturally wash the basins out. The basins would have to form naturally, of course ; they would become gravelly, and the whole water would be improved undoubtedly.

Mr. GREENOUGH.—Isn't there considerable loam, on the sides of Basin 3, which is washed off?

A. Yes, sir ; I think there is.

Q. Would it not be an improvement to Basin 3 to have some loam removed from it ?

A. I cannot say it would. I have tried to look into it, and I do not think any gentleman who has looked into it carefully could not say the same. Prof. Remsen came to the same conclusion. I do not think anybody can say that the loam is the cause of the taste in our water to-day.

Dr. BLAKE.—If you take a gallon of water and a small portion of loam, and put them in a bottle, you get an infusion of that material, don't you ?

A. Yes, sir.

Q. Now, it may not be deleterious to health, but it is going to affect its color and taste ?

A. Yes, sir; but why hasn't it done so in Basin 2?

Q. It has gone through the process.

A. No, sir; there was only about one season difference.

Mr. GREENOUGH.—The water is coming through Basin 2 to-day?

A. Yes, sir.

Q. It has this earthy taste?

A. Yes, sir; it has a slightly earthy taste; but I think it is worse in the city than at the basin.

Dr. BLAKE.—Does it mix with any other water, to pollute or deteriorate it?

A. I cannot speak of it accurately. During the whole season you get a change of water. During the whole summer we had to draw from Basin 3.

Q. Are we drinking from Basin 3 now?

A. No, sir; not since September.

Dr. BLAKE.—I think it is nothing but just to the Water Board that any erroneous remarks made to scientific bodies should be corrected.

Mr. FITZGERALD.—I have on my desk enough to fill two or three volumes; and there are so many mistakes it would be too much to attempt to correct them. But the principal objections I have to the article referred to previously are the statements about the measurement of the water, which are perfectly absurd. He said the estimated capacity is a hundred and thirty million gallons. There is no such estimated capacity. You will find the facts about that printed on our records. We have what we call our available capacity, which is always reckoned from a point above the bottom of the aqueduct nearly to high-water mark, because when we get below that we do not consider the water at the bottom of the pond of available capacity.

Mr. WIGHTMAN.—It is a question of head also?

Mr. FITZGERALD.—It is a question of head. Then another point here is very erroneous, and which he makes a great deal of. He says that on June 28, 1882,—just see how accurate he is in mentioning the date,—“thirty men were employed to scrape the *spongilla* from the walls of the new conduit and in removing a large quantity of sediment extremely offensive in odor.” Now, gentlemen, I will state to you on my honor that we never have had a particle of *spongilla* in the new aqueduct. I ought to know if anybody does.

Mr. GREENOUGH.—It was in the Cochituate aqueduct?

A. Yes, sir. He reasons from this, that having cleaned it in November, what an enormous deposit there must have been since then.

Mr. WIGHTMAN.—We did not find any in November.

Mr. FITZGERALD.—No, I never found any there. I could go through the whole article, and show that it is full of the same statements.

Dr. BLAKE.—I have a letter here from Dr. Barnes, in which he says:—

If you will turn to page 40 of the last annual report of the Water Board, you will see that during November 191,400,000 gallons of water was run

from Farm pond into Lake Cochituate, and consequently Fitzgerald was not stating facts when he said that this amount of water was not run from the 5th of December, for it appears from the month of December that 187,600,000 gallons went into Lake Cochituate. The average for November would very much more than fill the comparatively small basin at Dug meadow, and I could not have been mistaken in the date, November 28, 1881, when I saw the water passing over the top of the horse-shoe dam into the main lake.

Mr. FITZGERALD. — I do not wonder at that letter, and I must say it is due to a clerical error in making up that table. If you consult our original tables, which the clerk consulted, you will find only two tables, one running from Chestnut-Hill reservoir and Lake Cochituate. A note was made beside it: "None of this water was run into Lake Cochituate; it was all run into the waste-weirs." Of course the clerk did not notice that note on the margin, and he put it down upon that table.

Mr. SHEPARD. — Do injurious effects follow from the exposure of large shallow surfaces to the sun?

A. Well, as I said before, I believe that in a new basin they do. Now I think one reason why Lake Cochituate tasted badly immediately after raising the lake was because when you flow new land like that you have to produce an equilibrium in nature. The moment you disturb nature you disturb her equilibrium. If that is reckoned I do not think it is injurious; but, to a certain time, I do think it is.

Dr. BLAKE. — That is, admitting the question of shallow flowage. When you raised Lake Cochituate five feet above its normal level, and when you drew the others down to this five feet, you had this depth exposed?

A. Undoubtedly. That was traced to those meadows.

Q. And you had the same condition existing in the lake that you have in the basins to-day?

A. No, sir; in the lake we now have more dams. You cannot build dams all around every basin. In Lake Cochituate there were larger areas which were shallow.

Mr. GREENOUGH. — You haven't any question but the exposure of shallow water cultivates *algæ*?

A. Yes, sir. My remarks were directed particularly to a lake or storage-reservoir which you draw up and down. I do not think it has the slightest effect by drawing it down upon a natural pond. I hope this Commission will not lose sight of that, and that it is a fact that a bad taste is very liable to come to every source of supply in the most unexplainable manner. We have had to shut off the water from Lake Cochituate several times on account of the taste, and to use the other water. That is a matter of record.

STATEMENT OF HENRY M. WIGHTMAN. — *Continued.*

Mr. WIGHTMAN. — I wish to say that I am on record in a communication to the City Council, in answer to an order as to the desirability of removing the loam from the basins. I think that where such removal is practicable it is desirable to a certain extent,—that is to say, to the area covered by the ordinary

fluctuations of the surface, and when I state what I am doing at Basin 4 it will express what I think should be done; it is to stop the loam off from high-water mark to about twelve feet below, wherever it is practicable. Below that point I do not consider it is absolutely necessary, although desirable. I think it is desirable to take off all of the vegetable matter unless you can wait for the process of decay to go on and the water to become pure after that decay. That is, if you can wait two or three years before using the basin, I do not believe it is necessary to take the vegetable matter off. But if you cannot wait two or three years, I think it is a necessity to take off that vegetable matter, if you desire water of unobjectionable quality. I agree with Mr. Fitzgerald, or whoever made the statement, that I do not think it has ever been proved that the loam itself has been the cause of very bad water. Neither do I think that if the water has had a chance to lay upon beds of loam for any length of time, and then become pure, that by oxidation of the vegetable impurities the water is injured. After a basin has assumed the character of a natural pond I do not believe it makes any difference.

Mr. GREENOUGH.—How much do you think it is advisable to take out of the present basins?

Mr. WIGHTMAN.—I do not think out of the deeper portions of the basins there will be any advantage in removing the loam. That is, I mean any advantage gained in quality of water would not compensate for the expense of taking out the loam.

Q. Suppose we take it out of the largest basins, 2 and 3, as you suggest, about what would it cost, and what would be the quantity?

A. I do not think there would be a very large quantity, and I do not think there would be any very great expense. The only thing is, probably by another year it will be all washed into the bottom of the basin, and there would not be any necessity for removing it; but I say that when the basins are formed they have got to assume gradually the condition of natural ponds, and that is about as good as you can get them.

I do not believe it is practicable for a large city to get a supply in the way mentioned by Dr. Durgin. I believe we have got to rely more in the future than in the past upon storage. I believe if an amount of money, as I have indicated, is spent in removing loam, etc., from the basins, and let them assume the condition of natural basins, and the water purify itself from the decay of these vegetable matters, then I think you will get as good water as it is practicable to supply in such large quantities as we require.

Mr. SHEPARD.—Taking the expected growth of the city and the amount of water you now use, if you complete the Sudbury supply-basins would it be possible to allow them to stand until the basins became natural ponds?

Mr. WIGHTMAN.—Well, it would be possible for the city of Boston to be supplied from those basins without building another one for the next twelve years if you could reduce the consumption to sixty gallons per head per day instead of having it ninety-five, as it is now.

Q. Supposing you do not apply any remedy in that direction, and the consumption is the same, and you complete the Sudbury-river supply, will there be supply enough?

A. No, sir; if you commenced to build the basins to-day, and continued the present rate of consumption, you could not build the basins fast enough to supply the city of Boston with water. Only last year we were six hundred million gallons short of the supply we needed. Before we get this last basin done we are up to the capacity of it,—I mean in a dry year,—we were up to the capacity of the supply last year; but we got six hundred million gallons from Whitehall pond, which they kindly allowed us to have.

Q. Are you under obligations to keep up the height there?

A. No, sir; but the parties who own the pond had a certain amount of water stored there, and the pond was full. At the time the city was at its shortest supply the parties manufacturing upon the river went to them and made a trade with them to let the water down, and, of course, while coming down the river it had to be stopped by our dams, and we got the supply.

Q. Is Whitehall pond one of the sources?

A. It is practically one of the sources.

Q. Was that dam constructed for manufacturing purposes?

A. Originally it was; but it was rebuilt by the city. There was an old dam there, and the city rebuilt it, to make this storage-basin.

Mr. GREENOUGH. — Will you have some estimates made as to the quantity of loam necessary to take out between high and low water mark?

A. For Basins 1 and 2 there are estimates now; but for Basin 3 there are none. I have plans showing the depth of loam and the areas for Basins Nos. 1 and 2, but for Basin No. 3 we have none. A portion of Basin No. 3 was an old swamp, twenty to thirty feet in depth, I suppose.

Q. I do not mean in the swampy part.

A. I was only going on to speak of the accumulation of loam. I suppose there are twenty to thirty feet of loam and muck in the swamp. It is exactly the same as the Lawrence basin was. It would not pay to take out such an accumulation. It is just the same in Farm pond. There are forty feet of mud soundings in Farm pond. There are plenty of places in Lake Cochituate where it would be absurd to talk of taking out such an accumulation as exists.

Mr. SAWYER. — There is a shallow place near the dam on Basin 3.

Mr. WIGHTMAN. — Yes, sir; that is gravelly.

Mr. FITZGERALD. — Would it not be a good idea to say a word about Farm pond? There has been a wrong impression about that pond being filled up with mud.

Mr. WIGHTMAN. — I think it is hardly necessary to state that. I made a statement at the last meeting of the Commission that it was susceptible of proof that people around there for fifty years had known of *algæ* being there.

Adjourned to Thursday, November 9th, at 4 P.M.

FIFTH HEARING.

NOVEMBER 9, 1882.

The Commission met at 4 P.M. Present, Messrs. Caldwell, Greenough, Blake, Shepard.

STATEMENT OF DR. H. P. WALCOTT, *Health Officer of the State Board of Health.*

Dr. BLAKE.—Doctor, the Commission desire to hear your opinion as to the occasion of the present unpleasantness of the Boston water supply, whether it is deleterious to health, and any suggestions you may have for remedying it.

Dr. WALCOTT.—That, of course, includes several topics upon which I am not an authority, and have no right to advise the city of Boston. I ought to say frankly in advance, perhaps, that I do not think the present condition of things could of necessity have been anticipated; that I do not think any of the methods suggested, or which I myself might suggest, would at once improve the condition of the water supply. But the one thing which strikes me, not only in connection with this, but with the general subject of water supply in the Commonwealth, is the fact that we know very little about it. The conditions under which we collect water are essentially different from those that prevail in any other country. We have a system of large reservoirs, practically large enough to store water through two, three, or four months of drought. The water supplies of England are of a very different character, and those of the continent are also very different. They have behind them a much more constant supply than we have. I do not know that the problem of ponded waters has been met as we have it here. The experience of every town in Massachusetts, from the small supply of Plymouth up to the large water supply of Boston, has shown that ponding waters in reservoirs, as ordinarily adopted, leads to the development of abnormal vegetable growth in the water that no method suggested offers complete relief from. It is a subject that has not been thoroughly studied; and my own criticism upon the city of Boston in the matter, so far as the past goes, would be, that after having, for a number of years, carried on such an investigation, it has very little to show as to the history of its waters for the last two years.

Prof. Farlow commenced an investigation for the State Board of Health in the matter of vegetable growths, and carried it further than any other investigation of the kind has been carried in this country before, and he reached the opinion that high temperature had a very serious influence in the development of vegetable life. Some investigations at Fresh Pond also show the same thing,—that while the shallow basins about the margin of the pond may be full of clathrocystis, the deeper, and, therefore, cooler, portions are free from it.

I saw, this last summer, Mr. William H. Lindley, of Frankfort, who, with his father, and alone, has constructed many of the large water supplies on the continent, and he told me that he and his

father had always advocated covered and deep reservoirs; that the water-supply reservoirs of large cities were generally so constructed. They felt it necessary to withdraw their reservoirs from the action of light even; and at the same time the question of depth is regarded as being of almost equal importance as preventing the overheating of the water. I think it is too early, with regard to the Boston water supply, to give any opinion upon the subject that is worth having. I think there are several things we might criticise; several things in regard to the actual condition of the basins that might be improved. But I do not think any man can say that the mere deepening of the basin will answer the purpose.

Q. From your knowledge of our sources, and our ponds and reservoirs, would any decided improvement follow the excavating, and cleaning and removal, or conducting organic matter from those basins?

A. It would certainly reduce the amount of those substances represented in analyses by albuminoid ammonia, but that it would prevent the development of many forms of low vegetable life I do not think can be said.

Mr. GREENOUGH. — You said you found nowhere else the ponding of waters for a large supply?

A. In the sense in which we do it; that is, a supply that practically is not added to for five or six months.

Q. Do I understand that all the water supplies you know of are taken from running rivers by pumps?

A. No; not at all. I think I can illustrate by the case of Berlin, which takes its supply of water from the river Spree. They get a very much larger addition to their daily supply than we can get, and it comes very much nearer the condition of running water than ours does. The water in the reservoir is much more frequently renewed than in the Boston reservoirs.

Q. I understand you to say that they take it from the Spree, and it is pumped from the Spree into reservoirs, and that they are able to rely upon a running river, the same as if we took it from the Merrimack and stored it?

A. Yes, sir.

Q. But they do not rely upon the accumulation of water which is held for some months before being used?

A. No. I do not remember an instance; at least I have not seen one.

Q. Did you give any attention while you were over there to the question of filtration?

A. Yes, sir.

Q. Did you see what is known as the Bischoff system?

A. Yes, sir. I was so much interested in it that I brought home a Bischoff filter. I saw the London agents of the system. It comes nearer to a perfect system of filtration than anything I know of.

Q. Will you describe it to this Commission?

A. Prof. Bischoff discovered that water passed through filters of spongy iron was thereby freed from bacterial germs, not by a

process of filtration simply, but by an actual destruction of these organisms. Those experiments have also been repeated here by Prof. Smythe, of Newport, who finds filters of spongy-iron, when properly used, sufficient for the removal of the germs, which are already proved to be the agents of processes of decay, and in many cases of the most fatal contagious and infectious diseases.

Q. I suppose you are familiar with the quantity of surface necessary for filtration in that way?

A. Yes, sir.

Q. Do you recommend it to our consideration, or do you agree that it is outside of possibility?

A. I think it would cost the city of Boston more than it is necessary to spend for a pure water supply. The expense of the Bischoff filter would be very large for so great a quantity of water. If Bischoff filters were found to be necessary, I should recommend going to Lake Winnipiseogee.

Q. In the city of Berlin I understood they are using about fifteen gallons of water to each person of population?

A. The present method of filtration there is, I believe, through sand. I do not know that the Bischoff filter is used in the water supply of any town.

Q. I think they are using it at Antwerp.

A. I know nothing about the water supply of Antwerp.

Q. The reason I asked you is, that if we could store our ponded water and then filter it as we want it, and keep it in small reservoirs, which we could cover and make deep, we could then have absolutely pure water without *algæ* in it. It would be a mere question of cost, and whether it was worth while to do it. If we could reduce consumption to the proper limit, it might be worth considering. Mr. Davis figured on the cost of filtration for the Mystic supply, and if I remember aright it would cost some two or three hundred thousand dollars for ten millions of gallons a day. If by the expenditure of a million dollars we could put in a system of filtration to purify our water supply, I do not think the citizens would hesitate a moment.

A. I do not know.

Q. Going to Lake Winnipiseogee is a question of fifty millions of dollars.

A. And it is a water supply forever.

Q. And full of *algæ*. Lake Winnipiseogee is no freer from *algæ* than any other water supply. It was full of them last summer.

A. Yes. We know that some portions of Lake Winnipiseogee contained *algæ* last summer; but nobody knows what it has contained during the last five years. We want the results of a continuous investigation.

Dr. BLAKE.— Suppose we have a biological examination every day for a year, and it showed the result of a lower temperature than we get in our basins, are you sure that the present changes of the water could be obviated, or do you think the conditions would continue to exist under the conditions described by increasing the depth?

A. I think that increasing the depth would be a protection.

Q. Would it be an absolute protection?

A. Nobody knows.

Q. But have they not constructed reservoirs of 100 feet depth?

A. I do not know of any of that depth. The great reservoir to be constructed on the Mersey, for Liverpool, has a masonry dam 180 feet high.

Mr. GREENOUGH. — Did you give any attention, when you were over there, to the subject of consumption of water in the various cities, and how much they were using?

A. Yes, sir. They showed me, at Liverpool, their system, which is an admirable one; but, with a certain amount of local pride, I assume to say we have as good a one in Cambridge.

Q. It ill becomes me to speak of what you are doing in Cambridge, but we know.

A. I know we have reduced our consumption to 45 gallons a day.

Q. But you have no doubt, as Secretary of the State Board of Health, that the consumption of water could be reduced without disadvantage to health?

A. Yes, sir. I know it is claimed that the waste of water in sewers is an advantage; but I believe it is all nonsense. It is better that the city should use it in a regular manner. I may say that in a recent visit to Indianapolis I found the city supplied with 500 gallons a day to their people per head. They have the Holly system.

Mr. SHEPARD. — Probably it is wasted.

A. I should think likely.

Mr. GREENOUGH. — We have some people at the South End who are using 400 gallons a head?

A. Yes, sir.

Dr. BLAKE. — I want to ask you about this periodical examination of the water; if you think a carefully conducted series of experiments for a period of six months would lead to any practical result upon the subject of purifying our water supply?

A. I do not know that I can answer that in any other way than by saying we are in the dark in this matter; I do not know that I can illustrate my opinion in any other way than by the history of the water supplies I am familiar with. An examination shows the existence of certain forms of animal and vegetable life. In two or three weeks some one form becomes a predominant one. Then, in the course of another month, that organism will disappear entirely, and no trace of it be left. Now, this disappearance may or may not be accompanied by bad taste, yet it is evident that you are dealing with water full of products of decomposition. Now, in the case of the recent trouble with the Boston supply, you get bad taste in the water, and the water supply is then examined; but you are beginning too late. You are dealing with the products of something which has already passed out of existence. It is a question which perplexes every scientific man when he comes to investigate any particular offence, because he knows nothing about the condition of things which preceded it.

Q. Do you think a prolonged investigation of that sort will throw light upon the cause of this development, or do you think we know the causes?

A. No, I do not think we know them all.

Q. And that investigation would point out the remedy and prevent a repetition?

A. If the scientific investigation does not show the remedy, then the remedy would be mere guess-work.

Q. But from our present condition you are not prepared to suggest any remedy, under the conditions as they exist to-day?

A. It is my belief that the condition of the water would have been very much better in a deep reservoir with a clean bottom than in a shallow reservoir with a mud bottom. But, whether the removal of the muck and making deep basins would destroy these troublesome forms of vegetable life, I cannot say.

Q. But if those projects could be carried out to a sufficient extent, and a cooler temperature of water attained, the water would be improved?

A. I know of one artificial basin in the State, the history of which, in this connection, is very instructive, and that is the basin at South Gardner, north-west of Wachusett mountain. Many years ago a man flooded eighty acres for the purpose of forming a reservoir for mill-power; the ground flooded was a swamp. It has now a sandy shore. I remarked this to a man who is familiar with the whole history of the basin, and was told by him that for nearly twenty years the pond "worked" every year, and was offensive. But during that time the gravel and sandy margins had been gradually increasing; the vegetable matter had been undergoing decomposition for twenty years, and the whole thing had been precipitated in the centre of the pond. Now there is no offence in summer; but this result appears to have only come after a number of years of a slow process of destruction.

Q. So, judging from that one case, we can look forward and probably infer that a similar change will take place in our basins?

A. There is no question in my own mind but that the basins will in time clear themselves. Whether the city of Boston can afford to wait that time is another question.

Q. In your opinion would the city be justified in cleaning out those basins and removing all the muck and soil and getting down to the hard, sandy bottom? Would the improvement in the water justify the expense, which would be necessarily large?

A. That depends entirely upon the Engineer's figures, and I do not like to give an opinion.

Mr. GREENOUGH. — You are entirely familiar with the action of the city of Cambridge in regard to the Shawsheen river?

A. Yes, sir.

Q. Do you expect that they will remove all the muck from the great basin in case they get the river?

A. Do you ask my opinion as a private citizen of Cambridge?

Q. I ask your opinion *amicus curiae*.

A. If I have any influence with the city of Cambridge, I should protest against their constructing a reservoir of less than fifteen feet depth in any portion where the muck remains.

Dr. BLAKE.—If you had any influence with the city of Boston you would enter a similar protest in the preparation of a new basin?

A. I should in the preparation of a new basin, undoubtedly.

Q. In any portion of the basin you would not let the muck remain where the water was less than fifteen feet deep?

A. I should say remove it entirely.

Q. It is worth the cost?

A. I think it is.

Q. The Engineer seems to be of the opinion that it will require only about three years for that water to assume its natural condition, provided the muck is removed from the borders.

A. That is a matter of opinion. I should attach much more weight to the experiment tried for us at South Gardner than I should to the opinion of any engineer.

Dr. BLAKE.—And that experience is, that for twenty years there are this sediment and foul odors from the pond?

A. Yes, sir. Of course this statement was made to me this year in the investigation of another matter. I have no reason to doubt it. The city of Springfield has gained no substantial relief in its water supply. They flooded meadows, and it is not yet a satisfactory supply.

Mr. GREENOUGH.—Are you familiar with our water supply from lake Cochituate?

A. Yes, sir.

Q. You have seen the various impurities put into it from Pegan brook, etc.

A. Yes, sir.

Q. Are you of the opinion that that pollutes our supply?

A. Very seriously.

Q. Where is it taken, into the conduit?

A. Yes, sir.

Q. But it cannot be shown by chemical analysis?

A. No, unfortunately; that is the objection I have to a chemical analysis. That is the reason I believe in a much more complete study of waters. I believe we have got to the end of purely chemical analyses.

Q. You are familiar with the laws in relation to enforcing the purity of water supplies?

A. Yes, sir.

Q. And you probably know that they do not work satisfactorily?

A. I know they have not given the satisfaction which the public expected of them.

Q. The law is not as strong, in your judgment, as it ought to be, is it?

A. The law, as it stands upon the statute books, seems to be sufficiently strong.

Q. But you know how the thing works; that when the city of Boston—in the first place, we are called upon to show that the water is polluted when it enters the conduit, which you say chemical analysis will not show, although you know it is polluted, and

in case of a decision of the State Board of Health there is a right to appeal to a jury from the next town. That is not a satisfactory condition, in which it is desired to be, to purify the water supply?

A. No, the working of the law is not satisfactory ; but I do not say that the law is not satisfactory.

Q. But you have occasion to see, in your position, that the law cannot be properly enforced?

A. I know it has not been properly enforced.

Q. I am very glad to hear you say that chemical analysis is not satisfactory.

A. It is not to me. I do not know any more striking instance of it than that shown by some of the experiments of Pasteur, who has done the greatest work upon these low forms of life ; that is, that he could destroy a sterilized solution of animal matter, in which there is absolutely no germ or living thing, by adding a fluid, which, by no chemical test, could be shown to contain anything but pure water. Now, it is not necessary that anything which makes trouble should be one of these germs ; but what is true of one of a class may be true of the rest.

Q. You do not think the pollution which comes from Pegan brook can be got out by oxidation, or anything in that line?

A. I think the chances are against it. I think the outbreak of typhoid fever among people along the course of the brook, and draining into it, would be a serious menace to the city of Boston.

Q. Are you familiar with the laws which govern the English Board in this matter?

A. Yes ; I think I am.

Q. Are they not all tending to the result that every man must purify his own sewage—every town and every manufactory?

A. Theoretically, yes, but practically, with regard to certain streams, even English law has allowed vested rights to become so powerful there that they cannot remove them. For instance, the city of Bradford purifies its sewage at a vast expense, and empties it into a stream apparently as foul as its sewage. The city does that, however, under an injunction obtained by the owners of some estates below Bradford on the river. But very little of that action has been taken under the Pollution Act.

Q. What are they going to do in the city of Bradford?

A. Bradford keeps right on turning pure water into the foul stream.

Q. It is so in Manchester?

A. Yes, sir.

Q. That is to say, every city can be compelled to purify its sewage before it empties the water into the stream?

A. Yes, sir. That is so in Coventry, which empties its sewage into the river Sherburne. I mean that they are not yet in a position to enforce the Rivers Pollution Act.

Q. On account of the vested rights which prevent it?

A. My impression is, that the present laws are not regarded as sufficient, and that most of the action already taken has been by the process of the common law.

Dr. BLAKE.— You consider sewage in any quantity as dangerous to a water supply for a large town?

A. It is enough to condemn the water supply.

Mr. GREENOUGH.— What would you recommend us to do at Pegan brook?

A. I should go again to the courts for protection.

Q. You know very well that the city Water Board has not been able to get anything from the town of Natick, although they went before your Board?

A. There is something better. I should go for a metropolitan drainage system.

Q. The city of Boston did go for it, if you will allow me to correct you.

A. It did not appear so to those who were interested in it.

Q. The city of Boston was represented by Mr. Caldwell, Mr. Shepard, and myself, and favored it.

A. But Mr. Bailey turned round at the last moment and opposed it.

Mr. GREENOUGH.— That matter was referred to the Committee on Water, and was by them referred to Alderman Caldwell and myself, and we went to the Committee on Health at the State House, and the plan was violently opposed by the smaller towns.

Dr. WALCOTT.— Yes, sir.

Mr. GREENOUGH.— I never heard that Mr. Bailey retracted his approval. If he did I never heard of it.

A. We certainly did have his assistance, in the first place; but he made objection finally to the cost being raised by a tax upon general valuation instead of population.

Q. In raising the \$30,000?

A. Yes. I do not know that that would have made any difference. But I do not see any relief for the water supply for this whole territory except this metropolitan drainage scheme.

Dr. BLAKE.— And that would remedy only that one evil?

A. Yes, sir. It would remedy the evil from Natick. I think there is something to be said for Natick.

Q. Would it relieve the trouble with Sherburne and the Women's prison?

A. Yes, sir, I think it would. The city of Boston has an evil before it in the Women's prison which is only a trifle compared with Natick.

Mr. GREENOUGH.— You do not think the emptying of it into the ground relieves it?

A. I do not. I do not think the filtration through the earth is going to remove the thing that produces typhoid fever.

Q. Suppose we should apply the Bischoff system to Pegan brook?

A. If applied to Pegan brook it might be made a success.

Q. It would pay for the amount of money required?

A. I do not know whether it would pay; I think it would be a relief.

Dr. BLAKE.— It would be a relief in a measure. But unless the same system was applied to Cochituate village, and South

Framingham, and the Women's prison, the relief you would get would be only partial.

A. You could apply it to all.

Mr. GREENOUGH.—There is very little that comes from South Framingham.

Dr. BLAKE.—Do I understand that there is no system of sewerage there?

Dr. WALCOTT.—Any growth about South Framingham means the pollution of Farm pond. I do not know how you are going to prevent Framingham from using that small brook.

Mr. GREENOUGH.—Half the time there is nothing to speak of coming out of that brook.

A. No, but I am assuming that there will be, from the increase of population.

Q. That can be obviated by putting a conduit around Farm pond?

A. Yes, sir. But these are all makeshifts. They must have a complete system of drainage.

Mr. GREENOUGH.—I think that is so, and if the city of Boston can assure this drainage by the expenditure of four or five millions of dollars, I think it better do it.

Dr. BLAKE.—The expenditure of four or five millions of dollars would ensure the drainage of this source of pollution. In your opinion, if the city of Boston would expend that amount of money in that way, would it have a marked effect upon the character of the water?

Dr. WALCOTT.—In my opinion it would.

Q. And nothing less than that would secure marked relief?

A. Well, I do not know of anything.

Q. I do not see anything myself. If you have a high temperature in consequence of shallow flowage and shallow basins, we know, or at least we infer, that the high temperature of water would give rise to the development of these water plants, which by their decay affect the water, if they do not render it deleterious to health; and I do not see any other way of solving the problem except to remove those conditions which are favorable to such growths. I suppose it would not be feasible for our city to cover the storage-basins, or roof them over?

A. It does not seem to me at all possible.

Q. Could we gain any material supply by pumping from artesian wells, or by any other system of drawing water from beneath the surface of the earth?

A. The trials that have been made in this State, with that end in view, have not been successful.

Mr. GREENOUGH.—They have good water at Watertown?

A. There is a good deal of question about it. The last analyses showed that the water had deteriorated; but the present condition I do not know.

Q. I know they bored about eight hundred feet at Lowell, and got no water.

A. I do not know enough about the geological formations about Boston to speak with authority.

Dr. BLAKE.—Do, far as you know, all cities and towns depending, as we do, upon storage-basins, have the same trouble that Boston is now laboring under, from the want of preparation of the basins?

A. Yes, sir, I do not know one that has escaped. Holyoke, which has a supply from up above the city, remote from dangers of sewage contamination, has trouble even in the winter months.

Q. So that Holliston, Milford, and Arlington, and all the other places, have all practically prepared their basins in the same way that Boston has, and all been troubled in the same way that Boston has been?

A. As I say, I do not know of any basins that have escaped.

Mr. GREENOUGH.—You are familiar with the Sudbury river?

A. Yes, sir.

Q. You consider it a good source of supply?

A. I never felt that it was as good as the Charles river; but perhaps it is, on the whole, the best available.

Q. Dr. Durgin testified here last week that he thought the small amount of coloring matter held in that water in suspension had a deleterious effect upon the public health, although he had no special case which he could point to. Have you an opinion upon that?

A. I do not think there is any evidence—at least we have found none—that a slight development of clathrocystis in the water has injured people who used it. I think there is evidence, however, that it is an indirect injury, from the fact that a great many people who ought to use water are deterred from doing so.

Dr. BLAKE.—I think that Dr. Durgin put his statement in answer to a question of mine, that people with susceptible stomachs and delicate sensibilities might experience nausea and troubles of that sort, and irritation of the stomach and bowels, from drinking the water.

Dr. WALCOTT.—I do not think any of us want a water supply that doesn't taste well. I do not think it needs any argument to prove that.

Mr. GREENOUGH.—The water is very good in Boston to-day?

A. I do not drink it.

Mr. GREENOUGH.—It has materially changed within two weeks.

Dr. BLAKE.—It is much diluted.

Mr. SHEPARD.—But all the evils of sewage may be there.

Mr. GREENOUGH.—It has not the brown color it had two weeks ago.

Mr. SHEPARD.—But there is a good deal of difference. The water I draw at my house is different from that which I draw at my office.

Mr. GREENOUGH.—You may be on the high service.

Dr. BLAKE.—I have experienced no difficulty the past summer. I must say I have no reason to complain of the water if it is largely diluted with ice and the temperature is lower. I think that absolutely pure water is as flat a tasting fluid as anything you want to drink. Well, Dr. Walcott, to sum up, you would recommend a careful, protracted, scientific investigation of our water, and the

conditions it is exposed to, with the hope that the information derived therefrom would enable us to devise some measure for remedying the evil?

Dr. WALCOTT. — Yes, sir; I think it is fair to assume that.

Q. And that measures taken to ensure a lower temperature of the water would also be beneficial, in the deepening and cleaning of the basins?

A. Yes, sir.

Q. You are not prepared to say that, allowing the water to stand in the basins, prepared as ours have been, for three years, would be sufficiently long to allow the water to purify itself?

A. I do not believe it will be purified in three more years.

Q. Not in six years?

A. No, sir.

Q. Then you see no reason why the citizens of Boston, unless active measures are taken, cannot look forward to more troubles?

A. I do not see why the condition of things for the last year should not be repeated.

Q. You know no method by which these water-plants can be arrested or destroyed, under present conditions?

A. No, sir.

Q. No chemical or other process?

A. That is, none applicable to such large masses of water.

Mr. GREENOUGH. — By whom would you recommend that such an examination as you suggest should be made; by a biologist or chemist?

A. By both. The State Board of Health, Lunacy, and Charity, at my suggestion, made an appropriation in the beginning of the year for such an investigation into the conditions of various water supplies of the State. A person, competent to do the work, could not be secured, and the examination has not been made. I cannot name a biologist for this work. I have also had some conversation upon this subject with the Water Commissioners of Boston.

Q. You did not make the proposition to the Boston Water Board?

A. No. I had talked it over with them, and I understood that they received it favorably. But it never was completed, because I never found the man to do the work.

Q. You have no one whom you would propose now?

A. No, I have not.

Q. Is there not one man, qualified to do that work, in the city?

A. No one man.

Q. Several men could do it together?

A. Yes, sir.

Dr. BLAKE. — The work could be done in Boston?

A. Yes, sir. Of course the appropriation I control is a limited one.

Q. Then it is simply a question of money?

A. It is a question of money.

Q. Have you any idea of the expense?

A. I am not now prepared to name a sum.

Mr. GREENOUGH.—The water should be chemically analyzed, and also examined by a biologist?

A. Yes, sir; and, by keeping the two distinct, it is possible that in a year or two we might bring the two together in some useful way.

Q. It would cost very much?

A. For a great many years the work that Prof. Nichols did do was almost the only scientific work that had been done in the study of waters, and it has been almost constantly referred to throughout the country.

Dr. BLAKE.—Have you anything to add to what you have said in the way of general advice or suggestions to this Commission?

A. No; I think I have already taken it upon myself to give you a great deal of advice.

The clerk read the following:—

To the Chairman of the Commission appointed to investigate the Character of the Water Supply of the City of Boston:—

DEAR SIR,—At a meeting of that division of the Suffolk District Branch of the Massachusetts Medical Society which is devoted to the subject of Clinical Medicine, Pathology, and Hygiene, held in this city last evening, the accompanying votes were unanimously carried, and the Secretary was directed to present the same to the chairman of the Commission as the expression of the views of the Society.

Very respectfully,

ALBERT N. BLODGETT, M.D.,
Secretary.

ACTION OF THE CLINICAL SECTION OF THE SUFFOLK DISTRICT BRANCH OF THE MASSACHUSETTS MEDICAL SOCIETY, NOVEMBER 8, 1882.

Voted, That the members of the Clinical Section of the Suffolk District Branch of the Massachusetts Medical Society convey, through their Secretary, to the Water Commission, lately appointed by the Mayor of Boston, their appreciation of the extreme importance to the inhabitants of the city of the questions which the Commission was appointed to investigate.

Voted, That, as practising physicians of the city of Boston, we express to the Commission the earnest hope that it will not adjourn without a thorough and careful consideration of the whole question of the city's water supply, or without making some suggestions for future action in the premises which may offer a reasonable hope of providing pure water, and of protecting the citizens against a recurrence of the great annoyances of the past.

The communications were received and placed upon file.

Adjourned to Thursday, November 15, at 4 P.M.

SIXTH HEARING.

NOVEMBER 15, 1882.

The Commission met at 4 P.M. All present. The clerk read the following: —

80 NEWBURY ST., Nov. 15.

DEAR SIR: — In case I am prevented from coming to the hearing this afternoon, I would say that in my opinion, —

1. The Sudbury-river water contains nearly always more organic matter than is proper in drinking water.

2. It is impossible to supply first-rate drinking-water to the city at the rate of 100 gallons a day to each individual, so that means are required to check the enormous waste.

3. As the Sudbury-river basins are constructed, they supply to the city more or less diluted bog-water, — an evil to be corrected by consulting the engineers.

Very truly yours,

CHAS. F. FOLSOM.

W. H. LEE, Esq.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY,
BOSTON, 14th Nov., 1882.

Mr. W. H. Lee, Clerk of Committees: —

DEAR SIR, — Your invitation to attend a hearing of the Water Commission on Wednesday has been duly received; but the present condition of my health prevents my acceptance of the same.

Yours truly,

WM. RIPLEY NICHOLS.

To the Commission appointed to investigate the Water Supply of Boston: —

At a meeting of the Boston Society for Medical Observation, Nov. 6, 1882, the following resolution was passed by a unanimous vote: —

The members of the Boston Society for Medical Observation, believing that the water supplied the inhabitants of the city of Boston falls far short of what a potable water should be, and that its condition ought to excite apprehension, as it has already excited disgust, desire to express their gratification at the appointment of a Commission to investigate the subject, and to express to the gentlemen of the Commission the deep interest with which their deliberations are watched by physicians. They feel confident that in their consideration of the subject, the Commission will recognize the gravity of the evil to be remedied, and hope that, with the assistance of such experts as they may consult, some remedy may be found for the unfortunate condition of affairs which has led to their appointment.

It was unanimously voted that the secretary be directed to transmit this resolution to the Commission.

C. M. JONES, M.D.,

Secretary Boston Society for Medical Observation.

The several communications were ordered printed in the proceedings of the Commission.

None of the gentlemen who had been invited being able to attend to-day, the Commission, after the transaction of some routine business, adjourned to Friday, Nov. 17th, at 4 P.M.

SEVENTH HEARING.

NOVEMBER 17, 1882.

The Commission met at 4 P.M. All present.

STATEMENT OF DR. CHARLES F. FOLSOM, FORMERLY SECRETARY OF THE STATE BOARD OF HEALTH.

Dr. BLAKE.—Doctor, you were for many years secretary of the State Board of Health, and in the line of your duty became familiar with the water supplies for cities and towns. I want your opinion as to the best source, provided the city or town has its choice; whether lake or river?

Dr. FOLSOM.—The best source unquestionably is a lake with a gravelly bottom, supplied by springs.

Q. Are there opportunities for obtaining water from that source in Massachusetts?

A. Very few in this part of the State.

Q. At the time Boston took the Sudbury-river supply, was it, in your opinion, the best available source?

A. I was not entirely sure whether it was better than the Shawsheen. I did not go into that matter carefully. My impression is the Shawsheen might be a little better.

Q. Would the Shawsheen yield as much water?

A. My impression is it would; but I am not sure about that.

Q. Why was your preference for the Shawsheen?

A. I thought it would be more likely to be kept entirely free from the wash from the small villages and towns; but the difference is not so very great in that respect.

Q. Then, under our present condition, storage-basins are a necessity, using the quantity of water *per capita* we do?

A. Yes, sir, unless you are going to Lake Winnipiseogee, which is, perhaps, out of the question.

Q. In the preparation of such basins, what course would you recommend as the best in order to yield us comparatively pure water?

A. The storage-basins I have examined very carefully are those of England. Their climate is rather cooler than ours, and it seems to me we ought to use at least as much care as they do in the preparation of their basins. The sides are usually pretty nearly perpendicular, a good many of them of masonry. If I remember, there is no place in any of them where the water is less than eight to ten feet deep. These are the storage-basins chiefly in London and on the East River Thames. That is the rule which generally obtains in England.

Mr. GREENOUGH.—Are the sides all masonry?

A. Most of them.

Dr. BLAKE.—Are they careful, in the preparation of their basins, to remove the loam and vegetable matter?

A. Yes, sir; and the bottoms, in every case, if I remember accurately, were covered with gravel.

Q. Have they complaints of the quality of water?

A. Yes, sir.

Q. Of what nature?

A. The Lee river and the Thames both contain enormous amounts of vegetable organisms; I would say rather more than in any of our rivers. The amount is so excessive that they have used very great care in getting rid of it. The water supply of London is the subject of inquiry at the present time. They have the same difficulty, I think, that we have, only to a less extent, because their basins have been more carefully constructed. The greatest difficulty in London, however, it should be said, is now rather as to quantity than quality. They have to supply something like a hundred and twenty millions of gallons a day, which is, of course, rather a difficult thing to do.

Q. Do they complain of the taste, and color, and smell of the water when heated?

A. They very rarely have the disagreeable taste and color we have, — almost never. The chief objection to it is the objection that obtains to all river-water, that it is flat and tasteless. Now, as I say, the complaint is in regard to quantity.

Q. In the storage-basins do they have water-plants grow? Do they have *algæ* to the same extent that we have in our shallow basins?

A. To the same extent, but not of the same kind. There is a plant which grows in the Thames and East river, one of the fresh-water *algæ*, which does not apparently give any taste to the water, and does not color it. It creates more mechanical trouble in the pipes, as to its removal, than ours does; but it does not give off the same offensive odor in decaying that ours does, and it does not impart to the water a disagreeable taste.

Q. In what respect does it render the water disagreeable?

A. It is chiefly a mechanical difficulty. Unless removed it fills up the pipes. It is in enormous quantities. I have seen a collection in less than a month, when I was in London, and went over the works with Mr. Graves, who has been the chief engineer of their works for many years, — deposits which must have been more than a foot thick, — green, — less than a month's collection. The workmen about there carted it off and used it for manure in their gardens.

Q. When that plant decays and dissolves, to a certain extent, does it not give a bad taste to the water?

A. It would, if it were not removed by filtration.

Q. By what process of filtration?

A. By passing downward through a layer of sand and then below that gravel, and below that are stones, which are gradually increased until they are as big as your fist.

Q. Are the laws regulating the pollution of potable waters more stringently enforced in England than in this country?

A. The laws are very stringent, but they are not in all cases enforced.

Q. They have the same difficulty with vested rights that we have?

A. They have great difficulty in enforcing the laws, very much more than we have, because the process is not so summary. It takes such a long time to get a matter before the courts and through the courts. A great many cases have been in the Chancery courts for many years.

Q. Should you say they are freer from sources of pollution of drinking-water in England than in this country — in the State of Massachusetts?

A. At the present time there is more filth from various sources that goes into the Thames river than in our water supplies. It is a highly cultivated area, and, of course, more thickly settled.

Q. Is the Thames water used for drinking, except a short distance below its source?

A. Yes, sir; a very large part of the London supply is from the Thames.

Q. Taken how many miles from London?

A. I cannot be quite sure. Some of the supplies come from, at least, below the town of Windsor, which is not far up, — perhaps fifteen to twenty miles.

Q. From your knowledge of engineers, and the care in the preparation of storage-basins, do they pay much more attention to those matters in and around London, and throughout England, than we do in this country, or not?

A. Yes; I think they unquestionably do.

Q. If you were consulted in the preparation of storage-basins, for a water supply for the city of Boston, what measures would you recommend to render our water supply as pure as possible?

A. Which, the present supply?

Q. Yes, sir.

A. I think some measures have got to be taken to reduce the enormous waste. That is without question, because the city is growing, and it is absolutely impossible for it to continue supplying the quantity of water which it is supplying now, for, of course, a great quantity of that is wasted. Beyond that, it seems to me the quality of the water from the basins should be improved, and I see no way of doing that but by deepening them and making their bottoms of gravel and their sides perpendicular, or nearly so, and having the storage-basins at such a depth that there would be no part of the water less than eight feet deep. I do not think it should be less than that. In our climate we should have probably some little difficulty with that depth.

Q. You would get rid entirely of the shallow flowages?

A. Yes, sir; I think it is quite necessary from two points of view. In the first place you cannot help the shallow portions of the reservoirs from being virtually swamps with a great deal of vegetation growing, and a great deal of heating matter in them. When the water is shallow the temperature would be very high in summer and that, of course, encourages the growth of the forms of vegetation which we want to get rid of if possible.

Q. You are quite sure that the temperature has a great deal to do with the growth of *algæ*?

A. There is no doubt it has a great deal to do with the growth

of those forms which are the most trouble to us, — the forms that we have had so much to do with in Horn pond, in Woburn, and in the Sudbury-river basins.

Q. In large natural ponds they have had a comparatively small amount of these plants?

A. In the natural ponds, supplied chiefly from springs, there has been none of this vegetable growth.

Q. Do you recall many cases?

A. Lake Wenham.

Q. That has an average depth of how many feet?

A. I cannot tell you. It is supplied chiefly from springs. It has a very gravelly bottom; there is very little flow from the surface. I do not remember the temperature, though I noted it one summer; it was very much cooler than in others. There are two little ponds at Concord, one called Sandy pond, and the other Walden, and I think a number in Plymouth county fed by springs. I am familiar with one or two in Berkshire county that supply the city of Pittsfield.

Q. Do you think sewage in any amount is liable to contaminate the water so that it will become deleterious to people using the water, even though chemical tests do not reveal the sewage?

A. Yes, sir; I think it is dangerous.

Q. So that if you were in a position to entirely shut it out, and prevent its entrance into the water, you would do so?

A. I certainly should.

Q. Do you know of any town or city supplied by shallow basins that has been free from complaint of its water supply?

A. No, they have all had it: Malden, Springfield, Melrose, and all the other towns. It is inevitable.

Q. Do you think that in artificial basins with a shallow flowage the water would purify itself in any particular time?

A. I doubt if it will. Of course the bottoms will improve; but in those parts where the flowage is comparatively shallow, I do not think we may look for any improvement; if anything it will get worse.

Q. So that any fixed time, three or six years, with basins of shallow flowage, will not render the water pure through the process of purification by exposure?

A. No, I do not think it would. The deeper parts of the pond will be very much improved indeed; the peaty matter will be washed away, but we have got to drink it. In the shallow parts I should not expect to find any improvement at all. I think that by examining the storage-basins now, one would find that that process is taking place to a great extent in the deep water, and is not taking place in the shallow water. In a great many places where the water is deep the turf and peat are all gone.

Q. I suppose that water holding a large amount of vegetable matter in solution may become dangerous to health?

A. I think it is generally accepted, to a certain extent, as injurious to health, and liable to create danger.

Q. Familiar as you are with our source of supply, and our system of storing water, your recommendation would be to cleanse and deepen the basins and prevent the entrance of sewage?

A. I should say that.

Q. Is there any other suggestion you could make to the Commission, in a general way?

A. Only with regard to checking the enormous waste. A city of any size cannot supply a hundred gallons a day to each individual of water which is thoroughly fit to drink.

Q. And Boston cannot with its present source of supply?

A. No, not without an enormous expense. Of course the population increases, and keeps using more and more water.

Q. Do you see any possible benefit to result to the citizens of Boston from the adoption of any method of filtering the water before admitting it to the city?

A. I doubt very much whether it would be of sufficient value to pay for the undertaking. Of course it is very expensive in our climate. That would be a matter of experiment, or rather you might say of experience. It is impossible to predict absolutely; but I should not expect anything of value from it proportionate to the expense.

Mr. GREENOUGH.—Whether you would look upon it as practicable?— You are familiar with Pegan brook and the lay of the land about there?

A. Yes, sir.

Q. Would it, in your judgment, be practicable to apply some filtering system, similar to the Bischoff system, by which to purify the water with iron?

A. Oh, yes. There is something like a hundred of those processes which have been tried. I do not think any of them are fairly successful. The iron process is very expensive. It is certainly much more expensive than sewerage the town and disposing of the matter. Even if it was carried down to where no one could make complaint, it would be cheaper than the Bischoff process. That process is very expensive. It has never been used in towns of any size. The only places where it has been used are a few factories, where the matter was concentrated.

Dr. BLAKE.—Would you expect any benefit to be derived from daily scientific examinations of the water?

A. It seems to me we have got nearly all that now. We should get a good many matters of scientific interest unquestionably. If it could be carried out a sufficient length of time, we might very likely get at some means of destroying this organic matter which is giving us some trouble. If all these improvements were made in the basin I do not suppose we should, necessarily, get rid of that particular form of vegetation which is most offensive to taste and smell; and, beyond that, we have got to find out how to get rid of that matter. Very likely investigations carried on in that direction, for certain intervals, for a long time, might be of value.

Q. We should be able to learn the natural history of the growth of this vegetation, and, perhaps, be able to devise measures to prevent its growth in certain basins?

A. Yes, sir.

Q. Will freeing the basins of vegetation and deepening the water tend to retard the development of those plants?

A. It unquestionably would of the plants which have given us the most trouble in the Sudbury-river basins, and in Horn pond, and quite a number of other ponds not used for water supply; but I do not think we know enough about the others to answer that question definitely. I remember once that in the Chestnut-Hill reservoir basins it was seen one year, and was not in any of these shallow basins.

Q. You say those plants are absent from ponds where the water is at its greatest depth and the temperature cooler?

A. Yes, sir.

Q. By adopting those measures, would we not prevent them from growing?

A. I think you would prevent the clathrocystis, which you see sometimes in the water; but the other does not last more than ten days or a week at the best, and it is in a very minute quantity. I should be very glad if I could say that would be the end of it; but it does not seem to me that would be warranted in the statement.

Q. Is it not a fact that ponds fed by springs from the bottom are clearer and have a lower temperature?

A. Yes, sir, very much less.

Q. So, taking all the measures we have spoken of, we could not hardly obtain as favorable conditions?

A. No, sir. You would get conditions more favorable than in some natural ponds, like those supplied from surface-water and flowage from fields; but you could not get the conditions obtainable in Lake Wenham, for instance.

Q. Do you think water purifies itself from sewage by running a certain number of miles, and standing a certain time?

A. Yes, to a certain extent.

Q. In what way is the purification brought about, by oxidation, chemically, or combination of all processes?

A. By oxidation, to a certain extent; but fish eat a great deal of sewage.

Q. When you get the sewage diluted, is there any way you can say that water purifies itself and is free from sewage?

A. No, sir.

Q. There is no way?

A. No, sir.

Mr. GEEENOUGH.— You are familiar with the laws in this State affecting the pollution of water supplies?

A. Yes, sir.

Q. Do you look upon them as being in a satisfactory condition?

A. No, sir; not at all. We have simply compromises between different individuals in the Legislature, and I think there is very little satisfaction in them.

Q. You would strongly advocate the laws being more stringent?

A. It seems to me it is quite important. We shall have to come to it some time or other.

Q. The tendency of all modern legislation is to protect the source of supply for all drinking-water?

A. Yes, sir. They have gone much farther in Germany than they have in England; and, of course, farther in England than we have here.

Dr. BLAKE.—Did you learn anything from Sir Frederick Bramwell in regard to water supply in London?

A. No more than I knew in regard to it. They supply about thirty gallons to each individual. London is growing rapidly, and they find it difficult to get water enough.

Q. Do they place restrictive measures upon consumers, to prevent waste?

A. The London water supplies are all private corporations, and, of course, they have to restrict consumers, just as the gas companies do.

Mr. BRADLEE.—They supply them differently from what we do. They supply the cisterns.

Dr. BLAKE.—And they fill the cisterns.

Mr. GREENOUGH.—And they use filters.

Dr. FOLSOM.—Liverpool is the only city that has meters.

Mr. GREENOUGH.—That is the Deacon meter, and it is not upon the houses. You may have noticed that we have been trying to introduce them here?

A. Yes, sir. I went through the matter with Mr. Deacon, when he was trying to introduce them in Liverpool.

Q. You would consider Lake Cochituate a good source of supply?

A. It certainly was until the dam was built. Of course that flooded a large area of meadow land.

Q. Do you consider the purity of Lake Cochituate is seriously affected by what goes into it?

A. I think the sewage of Natick is a dangerous element, and you cannot detect it.

Q. You would consider it worth a large amount of money to the city of Boston to have it taken out?

A. I should; yes.

Q. The Sudbury-river water itself is good water, after being stored?

A. I think it is probably as good water as one could usually expect to get from rivers.

Q. Are you familiar with the water supplies of any of the other large cities of this country?

A. I have been, with a good many of them.

Q. Do they exercise any more care in the preparation of their basins than we have in ours?

A. The basins of some of the cities were built for storage,—an entirely different purpose. In St. Louis they are built of light clay and sandy bottom. In Louisville, Ky., they were built for storing water also, and, of course, were built very carefully.

Q. But those were only built for the purpose of holding a few days' supply?

A. Yes. I think the difficulties applying to our system would apply to all. It certainly would in New York. The Philadelphia water is a good deal worse than ours.

Q. Would it be your opinion that we had got a tolerably satisfactory water supply if a little more care was applied to the preparation of it?

A. I should say a good deal more care. It is a very large undertaking to construct basins as they should be constructed.

Q. Would you consider it worth the expense now, to which we would have to go, to remove the loam from the basins?

A. I should think so, for drinking-water.

Q. As a matter of fact I understand that those impurities in the basins appear at a later date now than they did in the previous year?

A. Yes, sir, it is a fact.

Q. So we have reason to believe that, in a few years, they will disappear?

A. I do not think that inference is a fair one. It has been the same with regard to other ponds in which there has been no change whatever in the condition of the pond.

Q. But if we could not get along without shallow flowage in the basins we have, you would rather recommend us to abandon that portion of the basins in which the flowage is shallow and dam them off?

A. Decidedly.

Q. In both the lake and in the basins?

A. Yes, sir, I should. I do not mean to be understood as saying that I think it will render the water perfectly pure and free from any difficulties whatever.

Q. Certainly not. But there will be less growth of *algae*.

A. Yes, sir; and there will be almost none of this solution of peaty substance in the water, which is a difficulty that applies the whole year round.

Q. You mean the discoloration?

A. Discoloration is the result of it. There is a large amount of vegetable matter dissolved in it, which is the cause of discoloration, and that exists the whole year round.

Q. I understand the water is more peaty colored when it comes into the basin than when it leaves it?

A. Undoubtedly.

Q. And, therefore, it does not necessarily take up the coloring matter from the basin?

A. The coloring is not necessarily an index of the presence of organic matter. Some dark waters contain less ammonia than lighter waters. The darker and lighter colors may hold the same degree of decomposition.

Q. You have noticed the difference in the water in Boston to-day from what it was a month ago?

A. The water in my house to-day happens to be more highly colored than it was yesterday. I have noticed it for some time past. Usually I have had less trouble than some of my neighbors.

Q. But the fact that the water is whiter would not show that it is purer?

A. It would not necessarily. It might in this case.

Q. You had, I know, some talk with Sir Frederick Bramwell,

because you brought him into my office. He gave me an account of this system of filtration by oxide of iron.

A. Of sewage?

Q. No, of drinking-water.

A. I thought you were speaking of sewage.

Q. I was, in regard to Pegan brook.

A. Well, Bischoff's process is usually applied in individual houses. Very likely the city of Antwerp is using it; but it is something quite new to me. Mr. Bischoff's system for filtering drinking-water was introduced quite a number of years ago in London, and it was used in some other cities. Chemists do not speak as favorably of it now as they did in the beginning; but still it is undoubtedly good enough for most purposes. I did not know that any city was doing it upon a large scale.

Q. I think there are several at present.

A. Very likely.

Q. The water, as it comes from Pegan brook, contains a considerable quantity of sewage?

A. Yes, sir.

Q. I did not know but it might be possible to so filter that brook that it might be allowed to run into the lake?

A. It certainly would not be satisfactory filtration by Bischoff's system of spongy iron, because it does not completely oxidize.

Q. You think nothing but chemical treatment would affect it? Would it be possible to chemically treat that water so as to render it harmless when it goes into the lake?

A. I do not think there is any method, without using a disinfectant, which must be so strong as to injure the water. Undoubtedly, you can filter the water by the spongy-iron process of Bischoff's, so as to sufficiently oxidize all the vegetable matter, such as we get from peat and turf, etc. Whether it can be done mechanically or not, I do not know. I never investigated that question. It certainly would be sufficient so far as purifying the water from vegetable matter.

Q. Is there any specific alteration in the law which we now have in Massachusetts, for the protection of the water supply, that you would recommend?

A. I went over the matter pretty carefully two or three years ago, and there was a law published in the eighth or ninth report of the State Board of Health, which I thought would be sufficient at that time, but which did not pass. I cannot go over all the points here now, because I would have to refresh my memory about it; but it seems to me the passage of sewage into water supplies used for drinking ought to be absolutely prohibited.

Q. What would you expect the town of Natick to do, — purify their sewage, or seek some other outlet for it?

A. I think they ought to be required to seek some other outlet for it.

Q. Take the rubber factory now being erected on the borders of Lake Cochituate; what would you expect the law to compel them to do?

A. I am not familiar with the process; but I think, unquestion-

ably, they should be enjoined from allowing any filth to go into the lake.

Q. You know, as a matter of fact, that the present law will not protect the water supplies?

A. No, it will not. I do not think it was meant to.

Q. These basins which you have seen in London, which are gravelly bottoms, and masonry on the sides, are none of them to be compared in size to our basins?

A. Those in the immediate vicinity of London are not so large. But there are two sets of basins on the East river, one very high up, where the water is stored about three days, — in fact, there are three sets, — another set quite near the city, which are filtering-basins. The basins away up are not built so carefully; but still they are so constructed as to prevent the water from being shallow. That method has been recommended very urgently in England for the last four or five years by the leading engineers for the smaller towns. In all cases that is one of the points they insist upon.

Mr. BRADLEE. — How is it done in that case?

A. I forgot what they called the method.

Q. Rip-rapping?

A. Yes, rip-rapping.

Q. Do you know what slope that is put at?

A. No, I do not. I should suppose that would be the cheapest way of doing it.

Mr. GREENOUGH. — You did not see any basin treated that way which is a quarter of the size of our basins, did you?

A. I will not be sure about that. I think some of those London basins must be more than a quarter of the size of ours. There are many of them.

Q. They pump the water from the river, do they not?

A. Yes, sir.

Q. So they do not find it necessary to store the water as long as we do?

A. Not so long as we do. They pump fifteen-sixteenths of their water from the rivers.

Q. And pump it daily?

A. Yes, sir.

Q. There are six water companies in London?

A. I do not remember the number.

Q. And no one company would furnish anything like the quantity of water which we have to furnish the city of Boston every day?

A. Our present supply is thirty-six millions of gallons; and there is no London company which furnishes such an amount as that.

Q. Probably they have no basins as large as ours?

A. I should say no, not as large, but I should say a quarter as large. I did not measure them, and it is difficult to estimate their size.

Q. It is a very different thing when you are treating a basin of thirty acres from treating one of fifty?

A. Unquestionably.

Dr. BLAKE. — Do they cover their basins in England, and roof them over?

A. They do, some of them, but more upon the Continent than in England.

Q. Is it pretty general on the Continent?

A. The Germans are using it a great deal.

Q. What benefit do they expect to derive from it?

A. Keeping down the daily temperature. In the lower part of Germany they have as hot weather as we do. In England they seldom have as high temperature as we do.

Q. Have they come to this improved system of storing water on account of the difficulties in the past from shallow flowage, etc.?

A. Yes, very largely that. The city of Vienna has gone fifty to sixty miles for its water supply, to a very pure source in the mountains. That is rather an exception. Before that they had been using the river-water, and scarcely required any storage-basins.

Q. Is the water satisfactory in quality?

A. Its appearance is that of spring-water. A great many German cities are poorly supplied, but they are going ahead faster now.

Adjourned to Wednesday, Nov. 28, at 4 P.M.

EIGHTH HEARING.

NOVEMBER 28, 1882.

The Commission met at 4 P.M. All present, except Mr. Caldwell. Mr. Greenough in the chair.

STATEMENT OF EDWARD S. WOOD, M.D., PROFESSOR OF CHEMISTRY AT THE HARVARD MEDICAL SCHOOL.

Dr. BLAKE. — I think, doctor, you had better give us a synopsis of your official knowledge of the condition of our water supply, if you prefer that method, and then we can ask questions afterwards.

Dr. Wood. — I would prefer to have you ask questions. I can only say that, as you all probably know, I was one of the medical commission which recommended the taking of the Sudbury-river water in 1874, and our report was published in that year by the City Government. The natural condition of the water at that time is fully stated in that report, and I have no reason to think that the natural water of the Sudbury-river basin has been changed since; but I have not made any analysis of the head-waters of the Sudbury river since they introduced the system of reservoirs.

Mr. GREENOUGH. — In brief, what was your opinion at that time?

A. It was favorable. We were ordered to investigate the Sudbury, Charles, Mystic, and Shawsheen waters for the information of the Committee on Additional Water Supply. We reported

that the Shawsheen was, chemically, the best water. It was also, hygienically, the best water, because its gathering ground was in a country which was not liable to rapid future growth, and the sources of contamination in the way of mills and thickly populated districts were few; in fact, it was much better than the gathering grounds of any of the other rivers.

Dr. BLAKE.—Better at that time and prospectively?

A. Better at that time and prospectively. But the amount of water which could be obtained at that time from the Shawsheen was not sufficient, and, consequently, it was abandoned by the water committee, and subsequently by the City Council. Then we reported that the Charles and the Sudbury were equally good,—that there was very little difference,—and, if the city of Boston could obtain better legislative authority in favor of one or the other river, they had better take that one. They had at that time obtained such legislative authority that they could control the Sudbury river far better than the Charles, and therefore the Sudbury was taken. We reported the Mystic supply the poorest of all, and it has proved to be so. The thickly settled sections of Woburn, Winchester, and other towns, to say nothing of the tanneries and Russell brook, and the other head-waters emptying into the Mystic, were considered undesirable. If I remember correctly, our advice was to abandon the Mystic altogether.

Dr. BLAKE.—At that time you found the Sudbury water at its source sufficiently pure for domestic and cooking purposes?

A. Yes, sir; it is as pure as the head-waters of the Cochituate; that is, Beaver Dam brook was much purer than Pegan brook.

Q. Since that time there has been very little to corrupt the water from below the head-waters to any extent?

A. Not to my knowledge, I do not know of anything which would change the character of the head-waters of the Sudbury river from what it was at that time.

Q. So that whatever impurities are found in the water now are the result of our method of taking care of it, and storing it, and looking after it?

A. That would be the natural inference, and that is my own idea.

Q. Have you analyzed the water recently?

A. I have analyzed it within a month.

Q. Judging from the results of the analysis, could you form any reasonably correct estimate of the cause of the impurity?

A. I could not.

Mr. GREENOUGH.—What impurity did you find in it?

A. I found it was about the same as a year ago in November.

Q. Well, the water has changed in Boston within a month.

A. I made an examination for the Boston Water Board the other day.

Q. And you found that it contained a larger amount of vegetable matter than it ought to?

A. Yes, sir. On October 26th I made an examination of the water of Farm pond, Russell's basin, and the Bradlee and Lawrence basins, and on Nov. 10th I examined specimens from the service.

Dr. BLAKE. — As a result of that analysis cannot you determine what the cause of the impurity in the water is?

A. It is vegetable matter. It is not an impurity from animal contamination, so far as it can be detected.

Q. Is it vegetable matter held in solution?

A. That is my own idea.

Q. And decayed vegetable matter could only get into it from the storage-basins? It is pure at its source, and there is not sufficient opportunity for it to become pure or clear from the vegetable matter, in its transit from the basins to where it enters the city?

A. I do not see how it can unless it meets with a large amount of vegetable matter in decomposition.

Q. Is there any way by which that matter could enter the river, that you know of, at this time?

A. I do not know of any. I do not know of there being any very great increase of population on the banks of the Sudbury, more than there was in 1874.

Mr. GREENOUGH. — Did you take these samples yourself?

A. I did not.

Q. Were they taken from the river?

A. They were labelled upon the bottles, and sent to me by Mr. Fitzgerald.

Q. There was none from the river?

A. No, sir, not from the river. I said I had not examined the river since I examined the head-waters of the Sudbury, in 1874.

Q. Do you consider that that water has an excess of vegetable matter?

A. Yes, decidedly.

Q. Higher than is considered healthy?

A. It is higher than is considered healthy.

Dr. BLAKE. — Will you read the results of those analyses, please?

A. Lawrence basin, albuminoid ammonia was 0.022. The water from the service on Nov. 10th was 0.0278 parts in 100,000.

Q. 27 in 100,000?

A. 278 ten-thousandths.

Mr. GREENOUGH. — What would you consider to be a proper quantity?

A. 15 is the maximum, compared with 27, and the least is 22. The Lawrence basin takes water from Lake Cochituate?

Q. No; from the Sudbury.

A. I went over it since I received the first notice to appear before this Commission, and have taken the pains to look up the former analyses, so far as I had them in my own library, and those were monthly and weekly examinations made by Prof. Nichols, previous to using the Sudbury. It seems to my mind to point with certainty that the cause of the increased contamination must be due to the Sudbury-river basins in some way, and the analysis which I made this last month almost exactly corresponded with those made by Prof. Remsen a year ago in November, and the Sudbury basins had then been used for I do not know how long. But the last records I have of Prof. Nichols' analyses, I think, are

from July, 1877, to April, 1879. The average was .015; just the same.

Q. Be kind enough to read where those samples were taken from.

A. October 26, Farm pond; October 27, Bradlee basin; October 26, Dam 1, Dam 2, and Dam 3.

Q. How did Dam 2 compare with Dams 1 and 3?

A. It is the same as Dam 1, and better than Dam 3. Dam 3 was the worst one.

Q. What were the parts of Dam 3?

A. 0.0458, compared with 0.0388 for Dam 2, and 0.0388 for Dam 1.

Q. The water when you tested it in 1874 was at that time a highly colored water, was it not?

A. It was highly colored, but it did not have any such amount as this in it.

Q. This albuminoid is not necessarily dependent upon the color of the water at all?

A. Not at all. The coloring is vegetable matter, and the greater the color, other things being equal, the greater the amount of albuminoid ammonia.

Q. You would expect from the coloring that it contains vegetable matter?

A. The coloring matter is vegetable matter.

Q. The statement is made to this Commission that the water, as it leaves Dam 2, is whiter than when it goes into it — the water from the river?

A. Where is Dam 2?

Q. It is like a fork, the principal fork being the Sudbury, and Dam 2 would be the first dam on it, and Dam 3 on the other branch, and Dam 1 is where they come together. Dam 2 is the principal basin upon the main branch of the river.

A. And Dam 2 is on the line from Marlboro' or Milford?

Q. Well, I don't know about that.

A. I am not sure myself. It is eight years since I was there.

Q. Dam 3 would be north of Dam 2. The principal branch of the river comes through Dam 2, and the statement is made to us that the water is a little darker when it enters the basin than it is when it leaves that dam.

A. That may be.

Q. If that is the case, would you expect to find that the water had taken up vegetable matter in that dam?

A. I should think it might. I said, other things being equal; but in flowing through the Sudbury basins the other things might not be equal.

Dr. BLAKE. — But the coloring is not dependent upon the presence of albuminoid ammonia?

A. If there were a very large amount of coloring the albuminoid ammonia would naturally increase.

Q. Exactly; but you might have perfectly clear water with a deleterious amount of albuminoid ammonia?

A. Certainly.

Q. You know something about the want of preparation of those basins?

A. I do not, from personal inspection. I have not been there since the basins were built, not having had an opportunity.

Q. Suppose a basin had a large amount of decaying matter in it, and was formed from land used for agricultural purposes, and there was a great amount of grass, peat, and loam; would that be sufficient to account for the result of your analysis of the water?

A. I should say that the covering of any territory, with any large amount of vegetation upon it, with water would increase the amount of vegetable matter very largely, and therefore may have increased the impurity of the water.

Q. Looking at the result of your analysis, do you think that allowing the water to stand for any definite time, say for three years or more, would be sufficient to effect the process of purification? Would the albuminoid ammonia be exhausted, and the water be rendered free from its presence, by allowing it to stand for a sufficiently long time in the basins?

A. It is my impression that that would be so, judging from the history of ponds, and mill-ponds especially; that the bottom tends to become pure after a lapse of time. To use a countryman's expression, ponds work for about ten years and ferment, and decomposition goes on, and, of course, there finally comes a time, if the pond is kept at a constant level, when there is no longer any vegetable matter to decompose, providing there is a constant stream of water flowing through that pond. Of course the products of decomposition are washed out after a while, and I see no other result that can be reached.

Q. Well, in our storage-basins there is no water flowing through them; they are prepared and intended to be used as reservoirs.

A. I know it; but how can they help being overflowed.

Q. But there is not a constant overflow.

A. At present the same object is reached by the conduit, which acts as an outlet.

Q. Yes.

A. Then there must be water flowing through it?

Q. I did not know you meant it in that sense, as a mill-pond.

A. Yes, sir, there is a constant action of the water. Of course, if the Sudbury basins are not drawn upon, there would be sufficient to make them overflow.

Q. You do not think three years would be sufficient to purify them?

A. It was distinctly stated by us in writing, I think, that the water should not be used for five years, and possibly ten, without dredging the bottom. That was our distinct idea at the time, and I think it was so stated in the report of the medical commission; but I will not be sure.

Q. Did you recommend that the bottom of the reservoirs be dredged?

A. Yes; or else that the ponds have sufficient time to purify themselves, at least five years, and possibly ten.

Q. At that time you apprehended this trouble if those recommendations were not complied with?

A. The recommendations were not complied with. That idea was also distinctly stated to us by one of the engineers, Mr. Davis, and Mr. Stanwood had the same opinion; and it was supposed at that time that there would not be any necessity for using the Sudbury within that period.

Q. Have you at any time detected the presence of sewage in the drinking-water of Boston?

A. I have not that I can swear to; yes, I have too,—Pegan brook; I can swear to that, because I could see the solid faeces going into the Cochituate.

Q. Were you called upon to testify to the impurity of the water?

A. I was called upon to testify at Natick before the county commissioners, I think, at some hearing to prevent the town of Natick from polluting Pegan brook. That was about a year ago, I think. There were the drain-pipes from a large hotel in Natick. I happened to examine Pegan brook as the contents of those pipes flowed into the brook, and thence into the settling-basins.

Q. It is not your opinion that the water in passing the distance it does from there to the city of Boston can purify itself by the exposure?

A. The sewage is so largely diluted that I do not think chemistry detects it; but I do not think the water is purified.

Q. And it is not free from danger, although you are unable to detect it chemically?

A. Yes, sir.

Mr. GREENOUGH. — Would you expect that a contagious disease in South Natick could be carried into Boston by the water?

A. It is a mooted question, and I cannot settle it.

Q. What is your opinion?

A. My opinion is, that even if it is largely diluted, it is luck and chance if we do not get something of it.

Q. I was reading yesterday a statement that I should like to have your opinion about. It is that the Seine, after flowing a few miles below Paris, becomes pure. Do you agree with that?

A. I should simply refer you to the statement of the English water commissioners, and the results arrived at by them after careful inquiry, and to Prof. Nichols' statement in some of the reports of the State Board of Health, where you cannot detect the sewage, because it is so much diluted. The amount of water flowing into the subsoil of any stream is very great. Of course every mile or half a mile of the river, each bank of a river or brook has its own collecting area, with the subsoil water flowing directly to the brook or stream; and if you dig a hole beside the river, either a large or small hole, the level remains the same, owing to this subsoil flow, and that level is almost constantly higher than the water in the river. In Lawrence the character of the water is very different. The water of the river is about one degree hard, and the water of the full basin is about five degrees hard. Consequently it shows that they have a constant flow of water toward the river. In a well-arranged filtering-basin they will pump large amounts, as they do at Lawrence and Waltham, without lowering

the level of the filtering-basin to the level of the river by the side of which it is located. That shows how much dilution may have to do with the disappearance of any contamination.

Q. You do not believe, then, that the germs of disease, when poured into drinking-water, are ever taken out of it?

A. I do not believe you can be sure of it. The only safe way is to never let it in.

Dr. BLAKE.— And, as a scientific man, you are utterly opposed to letting sewage into the water supply of any city or town?

A. Yes, sir; either directly or indirectly.

Mr. GREENOUGH.— You were employed by the Water Board to give testimony in regard to Natick?

A. I was.

Q. And you saw the unsatisfactory working of the present law?

A. I did. I saw the result was negative.

Q. And in your judgment an effort should be made to get more satisfactory laws in regard to preventing the pollution of drinking-water?

A. I should say so, decidedly.

Q. And that considerable injustice was done to the city of Boston at that time?

A. I think it was. It is no reflection upon the Water Board or the city of Boston, at all; they did their best.

Dr. BLAKE.— Is it your opinion that the temperature of the water has a great deal to do with the growth of these water-plants?

A. Yes, sir; in all shallow ponds. The growth takes place in summer, and not in winter.

Q. As a remedy for that, you would recommend deepening the basins, and cleansing them from decaying vegetable matter?

A. Positively.

Q. And if that is done with our present basins we should have an appreciable improvement in the condition of the water?

A. It might not be immediate.

Q. No; but we would, in time, if we removed the cause of the present sources of impurity.

A. I should think so. If I understand the arrangement now, it is that the water can be taken through Basin 1, either from Basins 2 or 3 at will,— am I correct?

Mr. GREENOUGH.— Yes.

A. And that it can be allowed to flow either through Farm pond or not?

Q. No; it has got to go through Farm pond.

A. What has become of the canal?

Q. It is filled up.

A. It is filled up?

Q. Farm pond is not any worse off than Dam 2.

A. Dam 2 is at the foot of which basin?

Q. At the foot of Basin 2.

A. Leading from Basin 2 to Basin 1?

Q. Yes. Dam 2 has always had comparatively good water.

A. I am not familiar with them.

Q. I am sorry that you had no water furnished from the river

itself, so that a comparison might be made with the water from the basins.

A. I see no reason for a difference between the water of the river and that of the basins; but I have not inspected them lately.

Dr. BLAKE.—I think that would be almost decisive, and I should, for my part, certainly desire that the doctor be requested to examine the river-water at its source and just before it enters those basins. I think the results would be conclusive if they showed a decided difference,—I mean Whitehall pond, and the various ponds down the river.

A. Whitehall pond showed one of the worst results at that time. I would suggest that the Commission refer to the report of the medical commission of 1874.

Mr. SHEPARD.—If you are going to make any further analysis of the water of the river, I think it would be a good idea to analyze some from Cedar Swamp pond.

A. Cedar Swamp pond is one of the worst.

Dr. BLAKE.—If Dr. Wood examines the water outside of the basins, that would be the fairest method; and then if he compared it with the water in the basins that would show where the impurities come in.

Mr. SHEPARD.—Dr. Walcott, who went out with us the other day, said we had not gone to the source of the supply that was likely to be the cause of the trouble; that there was nothing at Whitehall pond that was likely to be objectionable; but the other source of supply is the swamp, the water of which has never been particularly looked after.

Dr. WOOD.—By referring to City Document 102, of 1874, I find a record of an analysis of Cedar Swamp pond, which is above Milford, on the Charles.

Dr. BLAKE.—Even if the water is impure, or contains a large percentage of solid matter at Cedar Swamp pond, if that becomes very much diluted, it would not be a fair indication of the condition of the water outside of the dam. He should examine the water outside of the dam and in the basins also.

Mr. SHEPARD.—I should like to know what the condition of the Cedar Swamp water is.

Dr. WOOD.—At the proposed location of Dam 3, in September, 1874, the albuminoid ammonia in Whitehall pond was 0.0248.

Mr. GREENOUGH.—That is almost what it is now in Boston. There is one place where you have got it 0.024.

A. Yes, sir; in the proposed location of Basin No. 4, on Cold Spring brook, it was 0.0185; Angle brook, below Marlborough, 0.0104; Angle brook, at the proposed location of Basin No. 7, not yet built, I believe, .0009; Sudbury river, at Cordaville, 0.027,—a sample taken just below the woollen factory; at Ashland, and above Ashland, .031, and below Ashland, .036. That is on p. 43 of City Document 102, 1874.

Dr. BLAKE.—You find nothing in the water that cannot be accounted for by the presence of decaying vegetable matter?

A. No, sir.

Q. No specific cause of pollution?

A. No, sir.

Q. Simply such as you would expect from natural lands partially excavating them and making reservoirs of them, and leaving them with all the natural growth of vegetation and loam, and that exposed to a high temperature in the summer; and the decay of that vegetable matter would account for the troubles we are now suffering from?

A. I should think so, sir. I should think, even in the case of the decaying vegetable matter, that it affords food for the growth of *algae*, and gives rise, as a consequence, to an increased growth of *algae*, which, in their turn, must decay; and some of these, as we all know, give rise to very disagreeable odors and tastes.

Q. So that at all times during your professional connection with the water you have been quite satisfied in your own mind as to the cause of the disagreeable taste and color and smell of the water?

A. The color oftentimes comes from the head-waters, and usually disappears by proper storage, so that a highly colored brook-water upon being properly stored, as it always had been in previous years, loses that color. The Beaver Dam brook water is highly colored, and by being stored in Lake Cochituate loses a large portion of that coloring matter, and we receive the water in the city very slightly colored.

Q. So that taking a highly colored water and storing it in proper basins, which have been prepared by cementing the bottoms or removing the loam, or by building an artificial basin of stone, you would consider that the water would lose its color, and not have this decaying vegetable matter?

A. Very largely, sir.

(The Commission directed the City Engineer to procure samples of the water of the river and the basins, at various points, to be analyzed by Dr. Wood.)

Dr. WOOD. — I should like to state that, in my opinion, November is a pretty bad time, because it shows the water at its worst. As the surface-water is being cooled by the beginning of cold weather, it causes the water on the surface to sink, and the water at the bottom of the pond or reservoir, whichever it may be, rises, and you get all the impurities which have been collecting in the water which has been standing during the whole summer. That is very well illustrated in Fresh pond, at Cambridge. In November and December we get a very large amount of apparent impurity in the water. We get then the result of the summer's decomposition at the bottom, and we get it in our service-pipes. That disappears largely in the spring, and reappears every fall. So that, in an analysis of a water in November, you may reckon upon getting the worst results.

Mr. GREENOUGH. — Then we would not expect the water to show as bad as this?

A. Any pond-water?

Q. Our water.

A. Probably not.

Q. Not show as badly in the spring as now?

A. Probably not.

Dr. BLAKE. — In your opinion is there any process of filtration that can be applied to our system of water supply with beneficial results?

A. I should not dare to answer that question. I have not thought of it with sufficient care to warrant me in giving an opinion.

Q. What measures would you recommend for improving the quality of the water in purifying?

A. That is a pretty difficult question, and requires a great deal of consideration. I have an opinion,—but it is one that I could not support in any way; but I should say the first thing was extreme watchfulness,—and I have no doubt but that has been already resorted to; to take water from whichever reservoir or source that is apparently the best; to utilize the purer sources as much as possible, and the most impure sources as little as possible; that is, if the Sudbury-river basins are impure, to use Lake Cochituate; if Basin 2 is bad and Basin 3 is good, not to use Basin 2, and *vice versa*. I cannot now see anything else but time.

Q. Would you not recommend the excavating of the basins?

A. I mean in addition to what I have said. I have said that before.

Mr. GREENOUGH. — Even if that were done, you would expect that we should have impurity in our water supply?

A. I do not expect the Boston water will be pure for many years.

Q. Therefore we ought to have so large an excess of supply that we can cut off any portion at any time it became impure?

A. I should think so.

Q. Do you happen to know anything about the consumption of water in other cities and towns? You know something about the consumption of water in Cambridge?

A. It is very low; and it is due to good water superintendence. It is due to one man, and to only one man; and I think it might be done in Boston if you had the right man, and he had full control of the matter.

Q. You have no doubt the consumption in Boston could be largely reduced without any disadvantage to the public?

A. It could be very largely reduced. I am not an expert in the handling of water systems, and pretend to know nothing about it practically. But I know that the system of inspection in use in Cambridge is such that a leak can be located within a few hundred feet, and that the system of inspection has resulted in vast benefit to that city.

Q. It has cut your consumption down to the vicinity of forty gallons a head?

A. Forty-six, I believe.

Dr. BLAKE. — In the preparation of storage-basins for present or future use, you would recommend that greater care be taken in their preparation than has been used?

A. I think so, if there is a probability of their being used within ten years.

Mr. GREENOUGH.—Do you not know, as a matter of fact, that there never has been a time within the last ten years when the city of Boston has not been to the limit of its supply?

A. I know it was so in 1875, and earlier; but I think there ought to be enough supply in those basins to prevent additional basins being used so soon. It was supposed, at the time, that there would be sufficient supply in the collecting area of Sudbury river to last Boston a good many years, even with an extravagant waste of water.

Dr. BLAKE.—Have you any remarks to make on this subject, in relation to methods of purification of the source of supply?

A. I have nothing to offer except what I think I have mentioned before. I think the result of the analyses of water in the past few years, together with those made before the introduction of the Sudbury-river water, show with a great deal of certainty that the present impurities and sources of contamination come from the Sudbury district.

Mr. GREENOUGH.—Is this matter in the water wholly in suspension, or in solution?

A. Largely in solution. Of course there is a good deal of insoluble matter which is brought from the present reservoirs and basins, and which is undergoing decomposition. The products of that decomposition are largely soluble in water. Take sulphuretted hydrogen. I think all of you know that at the time the first dams were built, and the water was let into those basins, a piece of cloth saturated with acetate of lead, and hung upon the lee side of the basins, very quickly became blackened from the sulphuretted hydrogen blowing from the ponds. That sulphuretted hydrogen must have come from the decaying vegetable matter at the bottom of the pond. That state of things lasted several months, and I do not know but longer.

Dr. BLAKE.—Would the vegetable growths require organic matter for sustenance and growth?

A. That is one of their foods.

Q. The removal of that, and lowering the temperature of the water by increasing the depth of the basins, would naturally retard or diminish the amount?

A. There is no doubt but deep storage is the best, and that shallow flowage increases the tendency to vegetable decomposition at the bottom of any pond or basin.

Q. Because of the rise in temperature?

A. Yes, sir; by the action of the sun.

Q. Suppose it were possible to shut out the sun by covering the basins, you would recommend that as a preventive measure, to some extent, would you not?

A. I hardly see how it would be possible over a very large area. They tried to remedy that trouble somewhat in Lake Cochituate by building a dam so as to keep the water pretty deep over a large area. It was recommended by us in our supplementary report, that the shallow flowage should be remedied in some way, and they did so by building the dam.

Q. Of course it would be desirable in the construction of all future basins and reservoirs to have as deep storage as possible?

A. Yes, sir.

Q. Deep storage and clean basins are the remedies, or we shall have to look for no improvement in our water?

A. Yes, sir; I think so.

Adjourned to Nov. 29, at 4 P.M.

NINTH HEARING.

NOVEMBER 29, 1882.

The Commission met at 4 P.M. All present.

STATEMENT OF PROF. ALPHEUS HYATT.

Mr. GREENOUGH.—Prof. Hyatt, we believe you know more about the zoölogy of our water supply than any one else, and we want you to tell us what you know about the habits of the *spongilla*.

Prof. HYATT.—Do you mean by that a general question?

Q. Yes, the *spongilla* such as we discovered last year.

A. The habits are various. It grows mostly in water which is in motion. It does not as a rule, in my experience, grow very abundantly in water which is perfectly still. It must be where there is sufficient food. It is usually attached to hard substances. That is a general statement of its general habits.

Q. It grows generally in ponds?

A. In ponds, reservoirs, and streams; but almost invariably in water which is in motion, and in moderately pure water. In fact, I should say it demands good water.

Q. The presence of the sponge in the Boston water would be rather a testimony to its goodness?

A. Where the sponge is living, where it is alive, it would be a testimony that the water is good. In qualification of this, I would say that I have known of this form of pond sponge, the *spongilla lacustris*, to live in my laboratory for quite a number of weeks under conditions which I never supposed possible. I never supposed any animal would live in water which had been kept in such a small quantity in proportion to the amount of the animal in it for such a length of time.

Dr. BLAKE.—You had not the conditions there which you usually associate with this growth?

A. Exactly. I had the wrong conditions altogether.

Q. Stagnant water?

A. I had conditions under which I thought it would be impossible for it to live that length of time. The water did not seem to become stagnant.

Q. That, in a measure, modified your views as to its growth?

A. Yes, in regard to this particular kind of sponge; it would not in regard to others.

Mr. GREENOUGH.—What is the food of the sponge?

A. The food is microscopic, both animal and vegetable. The

food is very minute. The City Engineer wrote me to bring up a diagram and some preparations. I have not the preparations, but I have the diagram, if the Commission would like to look at it to see the general character of the sponge. This is not our fresh-water sponge. [The diagram was exhibited.] This represents commercial sponge. I have here a specimen of a common sponge. You observe that in all sponges there are large and small openings. This diagram represents a sponge attached to a rock. I have slit it in half, and I show you the cut half so as to exhibit the inside of the sponge. I have not the outside. The animal is surrounded by a skin, represented by this yellow line. Here you see large canals running down into the animal. Those large canals have small ones, and others connecting with the water through small openings. These red dots are properly the stomachs of the sponge; it has a great many of them. The stomachs are lined with peculiar cells, which act as digestive organs. This blue represents the food going into the stomach from the outside. The food goes in at these minute apertures. The small saecula receive the food when it is carried through all the channels. The outer part is a sort of sieve in the water; it keeps out large food and lets in small food through the minute pores, which finds its way through these canals into these little saecula. After digestion takes place the excrement is thrown out, and finds its way from the inside to the outside through the larger canals. The excrement is a minute pellet, very small, but very abundant,—so abundant that in some of our sponges it is quite remarkable. I should say it does not pollute the water. I do not regard the sponge in a healthy condition as injurious to the water whatever. It must be an animal which clears out an immense quantity of vegetable and animal matter. It is a creature possessing an organization requiring a good deal of food, and it is feeding all the time.

Dr. BLAKE.—Is there any change in the process of digestion that renders the excrements inert?

A. That I would not say. I only know that the food is taken in, and the usual changes take place, and the results are thrown off; but I should not regard them as injurious.

Mr. GREENOUGH.—The sponge is generally regarded as on the line between the animal and the vegetable?

A. No, sir; it is an egg-producing animal.

Q. It is not a sentient animal, is it?

A. Yes, sir; but it has no nerves. In the young it is very active. It has no power of selecting its food, and it is found living in localities where food is provided for it. If the food is injurious the animal is injured, and if the food is healthful the animal improves. It has many stomachs, which are only discernible by the microscope. You can only say it is a very delicate animal.

Q. The *Spongilla fluviatilis*, I believe, was found last year?

A. That was a mistake in the name. It amounts to nothing. It was about the same so far as that is concerned. The only difference that is of any value would be in the habits and peculiarities of this sponge. I am undecided what to call it. I have two names

under discussion, one is the *Spongilla Dawsoni*, and the other the *Spongilla paupercula*.

Q. What do you mean by *paupercula*?

A. It is a name given it by Bowerbank, and is rather imaginative, and means nothing one way or the other.

Q. Do I understand that this sponge lives upon *algae*?

A. No, sir; it lives upon the spores of the *algae*, if supplied.

Dr. BLAKE.—What is the natural age and duration of these sponges?

A. The average duration is about one season. They usually die in the latter part of the summer, in my experience. But still there is a great difference in different ponds and different places as to their duration. It depends, apparently, if I am right in my supposition,—and it is wholly supposition,—upon the change of temperature. The danger, I think, from the sponge, is wholly due to the suddenness with which decay takes place. Whether this particular sponge is tougher than the others or not, and whether it can stand more bad water, I think is probable; but after death it unquestionably goes very rapidly, like all sponges.

Mr. GREENOUGH.—You saw the sponge last year and tasted the water?

A. Yes, sir.

Q. You have no doubt the taste in the water was produced by the decay of the sponge?

A. You mean in the whole of the lake as it came into the city?

Q. All of the taste in that water came from Farm pond, and that was the only place where the taste came from?

A. I did not know whether you referred to the taste of the water I experimented upon, or to the water that came from the pipes. I inferred that the taste in the water which I examined was due to the sponge very largely; but, at the same time, I should not want to commit myself to the opinion, without investigation, that the taste was entirely due to that. I do not think it would be fair to say that.

Q. I think you would have been led to that conclusion.

A. It is quite a reasonable conclusion, because everything else had failed to account for it. There was nothing to offer itself. It seemed to me to be very near to the facts, as I observed them.

Q. Do you not suppose there are sponges growing in Farm pond to-day?

A. Yes, sir.

Q. Why do we not get that taste to-day?

A. I have thought about that, and it is a question of quantity. A certain amount of sponge will affect a considerable quantity of water; that is the general opinion. I find the best English authority on sponges, Bowerbank, and, I think, Mr. Carter also, who is another authority, both of them speak of *Spongilla* as capable of affecting a large amount of water. There seems to be a general opinion among the authorities that it is so.

Q. You think sponges come into Lake Cochituate one year and die the same year?

A. I should think so.

Q. And in some years we find them in the fall that they die, and they affect the water at that time?

A. I think that is the only explanation, so far as theory is concerned. I have not investigated the matter in such a way as to make my opinion positive.

Q. They cannot flourish except where food is found?

A. No, sir.

Q. And where *algæ* and other microscopic food is abundant they will grow?

A. Yes, sir.

Q. And if they die in the fall you would expect trouble?

A. Yes, sir.

Q. How do you account for this peculiar taste?

A. I have not investigated that matter and looked at all the conditions; consequently I cannot express a decided opinion; but my opinion would be that the quantity in certain years would not be the same as in other years, as is the case in other animals. There is a relation between the food and the animal which is very well understood. When the food is abundant the animal is abundant. If the food decreases, or the enemies of the animal become abundant, it will be destroyed or decreased, and when the enemies die out, or the food becomes abundant, the animal would increase again.

Dr. BLAKE. — I suppose the question of temperature would influence it very largely?

A. Yes, sir; very largely.

Q. And if you had food for the animal in the summer you would expect it to increase?

A. I cannot answer that question better than by saying that when the conditions are otherwise favorable, and the supply of food is abundant, you might expect a large number of the animals.

Q. A hot summer would furnish those favorable conditions?

A. Possibly; but I do not know. I do not like to say anything about a particular thing unless I know, and I do not know that a hot summer is particularly favorable to the growth of these sponges.

Q. Inasmuch as they die during the cold weather, and grow during the hot weather, the natural inference would be that hot weather is favorable for their growth, and I think it fair to infer that their growth would be rapid in a hot summer.

A. It may be.

Mr. GREENOUGH. — In other words, if the conditions are favorable to the rapid growth of *algæ*, we might expect the *Spongilla* afterwards.

Dr. BLAKE. — Certainly.

Mr. GREENOUGH. — Prof. Hyatt, do you agree to that?

A. The conditions are very complex in all these things. I like to reason logically about these matters. I should not like to express an opinion as to whether a hot summer would be favorable to the growth of the sponge. That would be a subject for investigation and decision.

Q. You would expect that the animalculæ would be found in

the same condition as those which produce the growth of *algæ*? If shallow flowage and high temperature and decomposing vegetable matter are present, I think you could logically expect to get other small microscopic plants for the sponge to feed upon?

A. I will put my doubts before you in another way and you will see: In Maine, where they have rather short summers sometimes, and where the water is extremely cold, you have these sponges in great abundance, and of different species, and they grow rapidly; yet the water will be clear while containing a great amount of living animal and vegetable spores, as I know by investigation, and small microscopic animals and plants. I think, therefore, we could not say that the heat of the summer would have anything to do with the abundance of these sponges.

Q. Except so far as it increases their food?

A. If there were sponge food I think the sponge would be very abundant, because it seems, from my experience among the sponges generally, that that is about the turning-point in the favorable conditions. When and where the food is abundant they will grow abundantly, provided there are proper places for them to grow upon.

Q. You do not happen to know of any animal which feeds upon the sponge?

A. There are a few animals that eat the sponge, but they are very few. I do not know of any fresh-water animal that eats the fresh-water sponge.

Dr. BLAKE.—Is it not admitted that all these water-plants grow more rapidly in shallow flowage, and where you have a comparative high temperature in the water?

A. That depends upon the species of the plant entirely, and of the animal, and the temperature at which you will find them most abundant.

Q. Do you find them growing in abundance in cold weather?

A. In regard to *algæ* I cannot say. In regard to animals I can say positively as a rule they are not so abundant—that is, fresh-water sponges and such animals—during the winter as they are during the summer; they live only a single season. Their method of reproduction makes them wholly a summer animal. They do not live through the winter; they die in the fall. They are reproduced by a peculiar process, by peculiar bodies which are not represented in marine sponges. All fresh-water sponges are provided with peculiar oval bodies, surrounded by a hard coating of chitinous matter. The sponge decays, and these seed bodies remain either floating about, on the bottom, or else in the mass of the sponge itself, and in the spring develop young sponge.

Dr. BLAKE.—Do you find these sponges in the deep lakes?

A. I think they do not grow at any great depth. I have never looked for them in deep water. I have always found them in shallow water.

Mr. GREENOUGH.—The growth of the sponge is practically out of anybody's control, so far as I can see. How are you going to help having the sponges grow? You cannot cut off their food, and you say they will grow in abundance in beautiful clear water?

A. Yes, sir.

Q. So that if we found no *algæ* visible, that would not prevent the sponges from flourishing like a green bay-tree?

A. That is a question that cannot be decided off-hand.

Q. If you covered the bottom with mud, you would not prevent their growing there?

A. This *Spongilla lacustris* is said to grow right on the mud. Mr. Van Vleck said he saw it growing on the mud. I did not see it.

Mr. WIGHTMAN. — I think, if he had investigated it, he would have found it on stones. I looked at it very carefully, and I was not able to find the sponge itself unless there was something hard for it to grow upon.

Prof. HYATT. — I am glad to hear that. It solves one difficulty that annoyed me very much. He may have been right, after all, in this way: The young sponge must have something to settle down upon. I do not believe it is possible for it to settle down upon mud without being choked to death. Then after it gets to growing it may be possible for it to grow down, or stretch down, and be gradually covered; but wherever the mud grows it is going to kill the sponge. All the specimens that came from there had brown tips to them, and I think they had a hard place to begin on; that the mud gradually accumulated around them and killed off the base. I did not see it myself. I merely saw the specimens that were said to come from mud.

Mr. WIGHTMAN. — I looked over it very carefully.

Prof. HYATT. — Did you go around the pond?

Mr. WIGHTMAN. — I went all around the pond, but, not being a scientific man in that way, I did not know how to investigate it; but I was not able to find any sponge there except it had something hard to grow upon. If we found them on the mud we invariably found something hard underneath it.

Prof. HYATT. — That is both reasonable and natural.

Mr. WIGHTMAN. — You will find them on a little stick.

Prof. HYATT. — That has always been my experience, that they grew upon something hard, and I was surprised to learn that they grew upon mud.

Mr. GREENOUGH. — Would the sponge grow in water polluted by sewage?

Prof. HYATT. — I should not like to say under what conditions it would not grow. It certainly grew in a very extraordinary manner in my laboratory.

Dr. BLAKE. — Is there any way by which we can restrict the growth of *algæ* in our storage-basins?

A. That is beyond my department altogether. It is too complicated a problem for me to express an opinion upon.

Mr. GREENOUGH. — You are not familiar with the habits of *algæ*?

A. I do not know enough about that department to express an opinion upon it.

Dr. BLAKE. — Then, according to your belief, the only way to get rid of the *Spongilla* is by an annual cleaning of the basins, and the places upon which it grows; you cannot prevent the growth in

any other way, and the only way to prevent its effects is to clear it out before it decays or after?

A. Well, if that annual cleaning was sufficient to take off the germs, it would destroy the sponge.

Mr. GREENOUGH. — If you could find a bed of sponge and empty upon it a cart-load of dirt, it would prevent the germs from sprouting?

A. Yes, sir.

Q. And you would not have any more of them there?

A. You would have them next year, but it would not take long for the streams that fed the pond to bring down enough to repeople it with sponges. You could not possibly clear the pond so you would not have a crop of sponges every year.

Q. Do you suppose we have sponges growing all over Stony brook and Sudbury river?

A. I do not know that river and brook well enough to say; but it is probable that they are growing there. You will find them more or less in all fresh waters.

Mr. WIGHTMAN. — We found them in Basin 1 when we drew the water off to repair the pipe.

Dr. BLAKE. — You found them in greater abundance where you have rocky or stone bottom for the sponges to attach themselves to?

Prof. HYATT. — It is a curious fact that they grow in lakes with muddy bottoms where attachments can be made to sticks and the roots of trees. But the mud does not affect them unless it is stirred up. It is nothing but a mechanical process of choking. They would not grow in a muddy stream; they grow only in good, clear water. After a certain period in the year, for instance, late in the year, you will find them decaying. I have never seen these sponges decaying; but I judge, from my knowledge of marine sponges, that at certain seasons of the year they decay very rapidly. I have seen marine sponges, immense beds of them undergoing very rapid decomposition under very fine running water, part of the sponge alive and the rest of it dead. I have seen occasional specimens of these green sponges in which part of it was alive and part of it undergoing decomposition. Those were brought from Farm pond; but I had not any occasion to see the general decaying of the sponges there, which, however, I have no doubt takes place at the proper season. I have had some practical experience in regard to decomposition and its causes. When this matter arose I thought, and since then I have come to the conclusion, that the capacity of the sponge for quick decomposition can be accounted for by its open structure. It has a very open structure. It is so open and porous that it decomposes throughout at once, and very rapidly. The rapidity of the decomposition of animal bodies is an important element in this problem.

Mr. GREENOUGH. — Is the skeleton of the sponge animal or mineral matter?

A. It is both animal and mineral. If I had a slate or blackboard I could show you. The skeleton in the fresh-water sponge is made up of minute *spicules* like needles, and they are bound together by the tough, horny matter which surrounds them. The

horny matter decays rapidly, but not so rapidly as the fleshy part. The *spicules* are largely mineral.

Q. Then that mineral substance could not be taken from *algæ* alone?

A. It is silicious. Of course it comes from the food, probably in all forms; but just where it comes from it is impossible to say. I should think more likely it came from vegetable food; very likely that contains in some cases considerable silicious matter. It might come from animals and plants which contain more or less silicious matter. There are plenty of sources that contribute such matter.

Q. Is there any mineral matter in the *algæ*?

A. There is more or less in the covering, it is supposed; but in the *spores* I cannot say. The *diatomæ* are a kind of plant which probably enters very largely into the food of these animals, and which has a skeleton composed entirely of silicious matter. At the same time I do not wish to express an opinion that the sponges get their silicious matter from that source.

Q. The manners and customs of the sponge do not seem to be very well understood as yet?

A. You can see that there is something understood. It is about as well understood now as most animals are. Science nowadays has gone to the extent of mapping out completely the habits of but very few animals. Even man himself is not well understood, and you do not know what to do with him in sickness.

Q. You mean to say the sponge will grow in rivers where the food is tolerably abundant, and will reproduce itself from year to year if the water is good, and if there is sponge food?

A. Yes, sir.

Q. And it dies every year, and we do not notice it because it does not die in sufficient quantities, and there are not enough dying to pollute the water we drink?

A. Yes, sir.

Q. And suppose we do taste it, it has probably grown in excess of its usual quantity that year?

A. Yes, sir.

Q. And, if that year the water has been subject to *algæ*, you would look upon that as a primary cause of the growth of the sponge, would you not?

A. Yes, sir, I should be disposed to. At the same time I should add that it is a matter which is open to investigation; that it is not an opinion which is founded upon direct investigation; it is an inference.

Q. And you have also known sponges to grow in beautiful clear water, with no *algæ* in it?

A. I should not say that.

Q. No *algæ* you could see?

A. The microscopical food would be just as abundant, and you could not see it. I have seen plenty of water that was good, and yet full of all sorts of animal spores. Sponges must be fed just as cattle must be put into a certain kind of pasture. You cannot expect to find buffalo where there is no grass.

Dr. BLAKE.—And you cannot expect the sponge where there is no *algæ*?

A. You must remember that *algæ* are only one part of this food. There are a large number of microscopical animals which it feeds upon. It is not alone the plants, but the animals must be reckoned in. We must speak of both together.

Q. There must be certain conditions of water favorable to the growth, support, and development of both *algæ* and the animals which serve as a food for the sponge?

A. Yes, sir.

Q. Now, what are those conditions?

A. That I cannot answer, because I do not know. I do not know what temperature is particularly favorable to the growth of this species, and it would be impossible to ascertain without a great deal of work.

Q. In a general way a high temperature of water is favorable to the growth of both those?

A. I should rather have some one who knows something about *algæ* answer that. So far as the sponge is concerned I have already said I knew some species which grow where I knew the water was very cold. It requires direct observation upon the different kinds of sponges.

Q. But you have the growth of different kinds of sponges more marked in summer when the temperature is high?

A. That is very true.

Q. Is it not fair to infer that heat is a factor in its growth?

A. You will observe that a certain amount of heat is favorable to the growth, and a certain larger amount not favorable. If you ask me about the temperature for the commercial sponge, I would say the most favorable conditions are between 50° and 60°. If the average of the winter months is below 50°, you would have an inferior quality of sponges. If the average went above 60° the same result would happen, and they would become very coarse. In both cases decrease below a certain average or excess above a certain average of temperature produce a similar result.

Q. But high temperature is what we want to get at. That seems to be necessary to develop growth. If a sponge reaches beyond a certain point, its fineness and value for commercial purposes and its quality are impaired. We are not considering that commercial quality, but we want to get at the conditions which promote its growth, and it seems to me from what you say that high temperature does that?

A. But you see a certain amount of heat is favorable for man's existence and best development. If you increase the temperature above a certain point you afflict him; if you increase it above another certain point you kill him. With animals it is the same. Man is an animal. A certain amount of heat is favorable to us, and above a certain amount is unfavorable.

Mr. GREENOUGH.—Do you suppose it would be possible to keep the sponge right along and not have it die?

A. No, sir; a sponge is most difficult to keep alive. This is what excited my curiosity about the sponge I referred to before.

I had never seen a sponge that would live under such conditions.

Q. It would not be possible to keep a pet sponge?

A. Yes, sir; they do keep them in some aquaria. I never succeeded in keeping them. It requires very expensive machinery.

Q. Would it be possible to keep a sponge for a long time alive?

A. I think it would be very difficult. I think I understand the drift of your question, and perhaps I can answer it in this way: A great many animals can be kept in aquaria, which under natural conditions might die; by making the conditions which are most favorable, conditions of heat and food, all of which enter into the problem, and the size of the thing it lives in, which is also an element, you can keep an animal a long time, which under natural conditions would die at the end of the season.

Dr. BLAKE.—Do you know of a case of fresh-water sponge being injured by high temperature?

A. No, sir.

Q. Did you ever know of a commercial sponge being injured by high temperature?

A. Only by inference from the correlation of all the known facts.

Q. The sponges flourish most luxuriantly in the tropics. I suppose you cannot raise the temperature of water above a certain point, because you have no factor except the sun's rays.

A. Certain kinds of sponges grow in great abundance at the north, and in the deep sea. They will grow in good water which has an average temperature of 32° , and equally abundantly in the water in the tropics. Then along our northern shores they grow abundantly in cold and warm weather. They are like all animals: some are suitable to the tropics, and some are suitable to the cold water of the north.

Q. Is there any means known to scientists by which their growth can be retarded except by the removal of the germs?

A. No; I cannot suggest any that I know of at all that would not be injurious to the water.

Mr. GREENOUGH.—All running water is sure to have sponges growing in it practically?

A. Well, I should expect it. Nearly all brooks have places where the sponges collect, and, at any rate, the water flows into ponds which have more or less of this in them, and I should expect it in any series of brooks where the conditions are favorable.

Q. Then practically it comes to this, if the city of Boston wants water that does not taste of this sponge it must have more than one source of supply?

A. That I cannot say. That is for the city of Boston to say. I can only give what little knowledge I have about the matter, and state the facts. All these problems depend upon investigation. Scientific men have no powers of divination. They have powers derived from special training, as other men derive their powers; and if there is a problem before them it must be worked out; they cannot expect to look into the future, and can look but very little into the past. They can see only as other men, and are trained only for

certain kinds of work ; it is not a fair thing to expect that they will do what it is impossible for man to do.

Q. There is no class of fish that eats this sponge?

A. None that I know of. They are remarkably free from enemies of that sort.

Dr. BLAKE. — The practical suggestion you may have to make, so far as you know, is to remove the sponges when we expect them to decay?

A. So far as I know now that would be the recommendation which I should give, with this strong proviso, that the whole subject has not been investigated and is not understood.

Q. In the light of the present condition of things, that would be the only recommendation you would make, and you would recommend that as a practical measure?

A. Yes, sir ; I should make that as a practical measure, if it is fully understood, with the proviso I mention. I would destroy the sponge every time I saw it.

Mr. WIGHTMAN. — I do not suppose that is possible. Take it in Lake Cochituate, these sponges must grow in ten to fifteen feet of water. I have seen them at that depth myself.

Prof. HYATT. — When I said deep water I meant fifty to sixty feet.

Mr. WIGHTMAN. — I have seen them dying there, and I do not think anybody could locate the place where those sponges were growing or dying in ten to fifteen feet of water. That is, you could not locate them, or tell where they were, and consequently you could not remove them.

Dr. BLAKE. — But you can remove them from the pipes and conduits.

Mr. WIGHTMAN. — Yes, sir.

Mr. GREENOUGH. — Do they require fresh air and sunlight to grow? Would it be possible for them to grow in the pipes of Boston?

Prof. HYATT. — At one time I thought the conditions were such that their growth in the pipes would be impossible. But I have had two or three facts come before me to show that they can possibly live in the pipes ; that is, in dark places and inside the pipes ; but how far I cannot pretend to say.

Q. Have you any reason to believe that they are growing in the pipes in Boston to-day?

A. I have seen a statement to the effect that they are growing in the pipes, and I have heard from the City Engineer and others that they have gathered them inside the pipes.

Mr. WIGHTMAN. — What the professor means is what I told him the other day : that the conduit from the lake for over a mile was lined with these sponges, and recently, within two weeks, we have drawn the water out of the Mystic conduit, which has not been done for a long time, and there is a very large growth of different kinds of vegetable matter there. I have not seen the interior myself ; but my assistant, Mr. Brackett, who went through the conduit, says there are sponges in there on that conduit. We have never had that taste in the Mystic water. It is evident from the

reports which have been read before this Commission that this sponge has been in Lake Cochituate more or less ever since the water was first introduced; so I do not think there is any question but that it will grow in the dark and in the pipes. But there is one curious thing about it. The conduit is six feet four inches high and four feet wide, and the pressure would be as great there as anywhere, and the current would be stronger than anywhere else.

Prof. HYATT.—That chimes exactly with all the observations I have made. That is, they seek a place where the current is rapid, and where the water is concentrated, so as to bring a large quantity of food. At the beginning of the conduit, where the water came in, they would get a greater concentration of food than anywhere else.

Mr. WIGHTMAN.—The conduit is eleven to twelve miles long, and I do not think they find any food in that portion of it.

Prof. HYATT.—That species is a different thing from the species outside. That is what I suspected when you told me, but I did not think to ask about it. It is probably a different kind of sponge.

Mr. WIGHTMAN.—It looks just like it except in color.

Prof. HYATT.—But it is a different species of sponge, and has a different form.

Mr. GREENOUGH.—How many species of sponge are there?

Prof. HYATT.—I should think there are fifteen or sixteen kinds of this sponge in different parts of the world, but only six or eight known in this country.

Mr. SHEPARD.—I have heard the statement that after Prof. Remsen had made his investigation and said the taste in the water came from the decay of the *Spongilla*, Prof. Gray remarked that it was a wonder the thing had not been thought of before, because twenty-five years ago specimens of *Spongilla* were taken from the Cochituate conduit, and presented to Dr. Wyman, and he then said the result would follow. Do you know anything about that?

A. Yes; I know that was a statement made by Bowerbank. A portion of that same sponge went to Bowerbank, of England,—a great authority on sponges,—and he made several remarks about it. But they seem to have got these sponges out of the pipes themselves; but I did not believe that.

Mr. WIGHTMAN.—They took them out of the conduit.

Prof. HYATT.—I doubted it very much. I could not conceive of these sponges growing in the pipes. What the engineer says chimes in exactly with what I have said about the sponges. As I have stated, in the case of this *Spongilla* the species in the conduit is the same probably as that which grows on the undersides of stones and in dark places, and is not the same as the green sponge growing outside.

Mr. SHEPARD.—If the Water Board were informed, at that time, that such a taste in the water would follow from this cause, they ought not to have been puzzled in accounting for the taste, when they called upon Prof. Remsen to investigate the matter.

A. Well, the managers of the Water Department are not the same all the time. Their experience is not the same as that of a single man would be, and the experience was lost by new persons coming into authority.

Q. At the time Prof. Remsen made his statement it was hailed as something entirely new?

A. It was new so far as he was concerned.

Q. But the thing was known a quarter of a century ago?

A. Yes, sir.

Dr. BLAKE. — When Dr. Jackson investigated the water, thirty years ago, they found the sponge, and did not then connect it with the taste.

A. Certainly the opinion was expressed by the spongologists about that time; but I do not know whether it was brought to the attention of the Water Board.

Mr. SHEPARD. — I am told on excellent authority that Prof. Gray expressed his surprise that the solution of the problem by Prof. Remsen was considered as new.

Mr. GREENOUGH. — It was certainly new in City Hall.

Mr. WIGHTMAN. — It was certainly new in this country. If there was any such statement made before 1854, when we had the bad taste and when we had Prof. Jackson and Prof. Gray examine the water, and if they knew it, they certainly failed to connect it with the taste, and it must have been lost sight of.

Prof. HYATT. — It seems to me if a very thorough exploration and testing of all the different sources of corruption had been carried on year after year steadily, we could have found everything, and now be able to control the matter. I do not wish to express my belief that every time the water has tasted badly it is due to the sponge alone.

Mr. GREENOUGH. — Every time it has had that fishy taste?

A. I do not say that by any means. It is entirely open to investigation. It would be entirely unscientific for me to say so.

Q. If you could take a piece of that sponge and produce that taste in the water, you would not have any hesitation in saying that was the cause?

A. And finding plenty of sponges in it. But I would not be understood as stating that this is exclusively the cause.

Q. Does any other cause occur to you?

A. Well, sir, I should want to investigate the place itself, and should not want to express any opinion until I had done so. The whole thing is a local affair. It is not a thing you can judge of by knowledge of the world. It must be judged by the general place and its conditions.

Q. Do you know any other marine animal which would produce that taste?

A. I think almost any animal or vegetable life in abundance would produce deterioration in the water; but I do not know any other animal that produces that peculiar cucumber taste. I know the sponge does. I do not know whether *algæ* do; they say they do not. But there is one peculiar thing about this that has been pointed out to me by the City Engineer: that this taste was ob-

tained only at a certain point in decomposition ; and that I have also noticed myself. After Mr. Remsen gave me his vial I made some experiments, and entirely failed to get that taste, and I thought he was wrong. But I subsequently got it in the same way the City Engineer did, and when he spoke of it this morning I remembered the fact.

Q. If you had been called upon to express your opinion as to the cause of this taste in the water, would it have occurred to you that it came from the sponges ?

A. That is pretty hard to say. I should not have expressed an opinion until I had gone through an investigation.

Q. I merely ask you in reference to this being an old discovery.

A. I did not know that. It has come to my knowledge since.

Mr. WIGHTMAN.—I suppose there is one thing you want the professor to state. I do not think he has expressed a very decided opinion about one thing, which perhaps he might have a decided opinion about. That is, taking into consideration the fact that these sponges will grow at perhaps what he calls considerable depths, they may grow and decay entirely unknown to those in charge of the water works, and whether there is really any way of being safe from that bad taste except by providing several places from which you can draw the water? That is perhaps not a scientific question, but perhaps it is a fair question to ask him, if there is any way by which you can tell whether they are growing there so as to clean them out?

Prof. HYATT.—You can explore the pond with rakes, or some simple apparatus like an oyster rake, and could tell at once whether there is any growth upon the bottom. I should say in regard to cleaning the bottom that there is the practical difficulty, that you may not make the cleaning very thorough. Another thing is, that there grows with this sponge another animal, to which attention has not as yet been called, and which is usually mistaken for some form of sponge, and which under some circumstances might prove very injurious. That is one of the fresh-water *Bryozoa*. It grows in enormous masses, and is a sort of jelly as big as your head, or even larger. I have seen it as large in diameter as that table, — about three feet. When they are in that way they are in continuous masses, clumped together. I have not seen them in the pond; but naturalists who have been around the pond tell me they are there, and that with the sponge was thrown up a great quantity of the *Bryozoa* when the pond was cleaned. It decays in the same way that the sponge does in the fall, and passes through the same decomposition, and might be a source of pollution.

Mr. GREENOUGH.—And, in the absence of the sponge, might produce the same taste?

A. I doubt whether it would. It is decaying animal matter, but I do not think it is as offensive as the sponge. There is no question but that the sponge, when it is decaying, is the most offensive of all animals.

The CHAIRMAN.—You speak of using a rake in a deep pond to see where this sponge is. Suppose it was used, and killed a part

of the sponge, and there was no way to gather it from the bottom, would it not cause more trouble than it would to let it alone?

A. That is what I referred to. The only way is to treat it practically by trying the experiment.

Q. The only way would be to have different basins, so that you could draw off one and give it a thorough cleansing?

A. I have great question about the propriety of exposing the bottom of basins, without having had any experience. If you expose the bottom by drawing off the water you kill an immense quantity of animal and vegetable life that would remain in healthy action if you did not draw off the water; that begins to decay, and when you let on the water again you have an immense quantity of decayed stuff, which is liable to affect the water.

Dr. BLAKE.—We do that thing practically every year.

A. That is for the engineers to decide. I am merely speaking now as a biologist. It is a question which came up in my mind as you spoke about drawing the water off from the lakes. Whether such a result follows, or not, from the facts, the engineer can judge.

Dr. BLAKE.—The biologist would be the one to judge, not the engineer. You remove the conditions essential to life, and death follows.

A. Yes, sir.

Q. And every danger you would apprehend from exposing the bottom of the pond you would expect to follow the drawing down of the storage-basin?

A. I should say so. I should say the healthiest water is undoubtedly that in which animals and plants are living in equilibrium, in that condition in which life of both kinds is abundant, and in the conditions which we know to be very favorable.

Mr. WIGHTMAN.—And that you would call good water?

Prof. HYATT.—That is good water.

Mr. WIGHTMAN.—That is what our people do not think good water.

Dr. BLAKE.—I believe that in an aquarium you do not have shallow flowage or mud bottom, do you?

Prof. HYATT.—No; but a healthful condition of water is undoubtedly that which supports life, and in that respect it is the same as air. In these artificial basins you have different conditions; they are not the same as natural basins; the flowage is not the same as natural flowage. If you could produce natural conditions with a strong flow of water you would produce animals and plants, and you would have what would be right, it seems to me. It is utterly impossible to exclude life from those basins. That is out of the question. It does not make any difference how much cleaning out is done, they will grow there; consequently the problem is in producing not too much of one or the other.

Q. In the preparation of the basins you would empty them entirely?

A. As nearly clean, to start with, as possible. Of course I do not know anything about the preparation of basins, as I am not an engineer; but certainly the best conditions, after they were filled,

would be those as nearly natural as possible, whatever the locality might be.

Mr. GREENOUGH. — Is there anything else that occurs to you?

A. No, sir; but last year it was proposed to clear out all the muck from the pond, and it struck me at the time that that would not get rid of the sponge. By cleaning out the muck you would not clean out the sponge, by any means.

Dr. BLAKE. — Aside from this specific taste we are called upon to ascertain is the cause of the generally disagreeable character of the water, without reference to the cucumber taste. Now, the problem for this Commission to solve is, whether we can devise conditions which will make our water purer, better tasting, less offensive to sight and smell when heated, and to contain a less amount of solid matter.

A. Yes, sir. Do you wish me to say what I think about that?

Q. I would like to have your opinion as a scientific man upon that question on the general subject.

A. Well, I should say the Commission had a question about as difficult as it is possible to put before them, and one which would require a great deal of investigation; and I should say it is a kind of investigation that is not generally carried on in this country. The way foreign governments do such a thing is to employ people who are qualified to carry on such an investigation year after year. They do not expect to solve the problem in a week, or month, or year. They carry it on as a regular business, with a fixed purpose, and they generally accomplish a great deal. Their habit is to employ people, under proper direction, and continue them year after year. The solution of that problem is not done within a given time. I think that any scientific man who would undertake to solve it in a given time would not understand his business.

Q. I suppose the Commission would be expected to be able, by inquiring of experts, to arrive at the causes of impurities in the water?

A. I should not like to be one of the committee.

Q. You have not as much faith in science as the city government has?

A. I have a great deal of faith in steady, strong work, that has an object and is properly conducted; but expert testimony — testimony of all kinds — is open to some objection. It is given upon general experience, and does not apply to the spot itself, as a rule.

Mr. SHEPARD. — Your idea is, that before we can expect to come to any solution of the difficulty there must be regular observations of the water in the various basins, continued for a long time, — it may be for several years, — in the accumulation of facts?

A. I certainly think that is the only scientific method. That is the only means which I recognize of obtaining scientific testimony which would be worth having.

Q. And those observations would naturally be physical, applying to the look, taste, etc., of the water; and that there should also be biological investigations, to show what life is present in the water?

A. Yes, sir. A matter of such importance as that I have no hes-

itation in saying that it is not possible, and in fact if it is not dignified, for the city of Boston to undertake to solve a problem of such importance as this, where other people as wise as they have failed, without a thorough, lengthened investigation.

Q. I heard a physician suggest to-day that there ought to be in the employ of the city of Boston some competent scientific man, whose sole duty it should be for two or three years to make observations on the water; and that while it might not be possible at the end of three years to discover the causes of the disagreeable nature of our water, yet there would be an accumulation of facts that might be of some advantage; and that we cannot expect to come to any solution of this problem until that was done. Do I understand you to agree to that?

A. I endorse that heartily. It is the only way to arrive at a decent solution of the scientific question. The examination should be made by a biologist; but there should be a physicist also. The matter should be looked into from all points of view. It is impossible to draw correct conclusions without having all the light we can upon such difficult problems. It strikes at the very root of all our knowledge of animals and plants. It is demanding of a scientific man the power of divination to ask him to express any sort of an opinion upon such a problem without an investigation of all the conditions relating to the place.

Q. It is proposed to ask the State, at the coming session of the Legislature, to establish a new Commission, with a fixed term of office for some years, whose duty it shall be to make those observations upon the water supply, within the limits of the Commonwealth. Suppose that is done, do you still think it would be of sufficient value for the city of Boston to warrant the expense of having some one to make a continued examination of our own water supply, provided the State do what is expected?

A. Well, I should think the city and State ought to coöperate together, but it seems to me the interests of the city should be represented fully.

Q. I understood that is intended. If that Commission is appointed, it is intended that they shall investigate all the water supplies of the large cities within the limits of the Commonwealth. But their duties would be very general over the entire State. Suppose such a Commission is appointed, ought we also to have some one to look after our own local supply, to make these same observations?

A. That would be entirely a practical question whether the State Commission could do all that is necessary for the city of Boston. It seems very desirable to me that the control of the investigation should be under one man, and he selected with great care; not a one-sided man, but one in whom the community had trust, who was scientific and capable of judging of this question from all sides; not necessarily a biologist, or any other ologist, but a man with a scientific education; a man capable of conducting all the different investigations that have to be made for the determination of the problem. So far as Boston is concerned, that ought to be carried out. Of course, if the State or city could both combine

upon one man, they could probably get a better one than either acting separately.

Q. Suppose that you, as a member of this Commission, in making your report to the City Council, should recommend the employment of such a person, and you had reason to expect that the State would appoint such a Commission as we have spoken of, would you then feel that you wanted to recommend the city to employ some one else beside, or leave the matter so that the State would do it alone?

A. That is a matter of which I do not see that I really have any means of judging properly.

Q. What I want to find out is, whether the local problem is sufficiently large and important that it needs the complete attention of one person, or whether it can be left to the person in charge of the problem for the entire State?

A. That would depend upon the State Commission. If the State Commission were composed of the right sort of men, they might possibly do it properly; but certainly the local interest of Boston in this problem is very great indeed, and the city cannot afford to leave such a thing to uncertainties. I should take the position that the city would have to be sure that their water supply would be properly attended to and investigated. Yes; so far as the importance of the local problem is concerned, I should say the city must have an investigation of its own. With such a large place as this, and so many inhabitants, they can afford to trust to no uncertainties; but whoever is employed, it seems to me, the direction of the work and the collation of facts had better be under one head in both the case of the State and city. The experience gained by a man superintending the whole State would redound to the advantage of the Commission of the city, in the collation of the reports of different observers. It seems to me there should be but one Commission, however many men you might employ to look after the local interests of Boston.

Adjourned to Wednesday, December 6, at 3.30 P.M.

TENTH HEARING.

DECEMBER 6, 1882.

The Commission met at 3.30 o'clock P.M. All present except Mr. Bradlee.

A conference was had with City Solicitor Bailey, and subsequently with the members of the Boston Water Board, in regard to the defects in the law relating to protection of water supplies, and the practical efforts of the Board to enforce the same, and the difficulties which had been encountered.

Adjourned to Dec. 8, at 3.30 P.M.

ELEVENTH HEARING.

DECEMBER 8, 1882.

The Commission met at 3.30 o'clock P.M. All present except Mr. Bradlee.

STATEMENT OF PROF. W. G. FARLOW, OF HARVARD COLLEGE.

Mr. GREENOUGH.—Prof. Farlow, we would like to hear your opinion as to the causes of the growth of the weeds which infest our water supply, and what, in your judgment, it is possible for the city to do to prevent their appearance.

Prof. FARLOW.—I have examined personally Basin 3, and know something about the Cochituate Water Works generally. In Basin 3, and all waters where there has been bad odor, it has come from two or three species of plants. The plants existed in those localities before the basins were built; and by the making of shallow flowage the plants have been given the best chance to increase, and they are increasing at such a rate that they are now found in great quantities. They will cause little or no disturbance unless the water is very hot in summer, which it is almost certain to be in August. The plants are there, and, now that you have got them, you cannot get rid of them. The plants were there in the first place. You will find these plants in almost any swamp. They do not attract attention unless they give off a bad odor. They do not appear in very large quantities unless you flood the marshes, and then these things collect as a scum. Before Basin 3 was built, in all probability there were some places where the plants appeared in considerable quantity; but that was nothing to what it is now.

Q. Would not the *algae* have appeared in these ponds anyway?

A. They were in Basin 3. Flowing the meadows with water would increase those plants. The *algae* may be carried over from one basin to another, but they do not pass through the air to any great extent. They would pass through a tunnel made to connect one pond with another. I do not know whether there is any direct connection between Basin 3 and Lake Cochituate; if there is, there is no reason why the same plant should not appear on the borders of Cochituate.

Mr. GREENOUGH.—I understand the same plant has appeared on the borders of Lake Cochituate.

Mr. WIGHTMAN.—I should say it is very nearly the same thing: I could not say it is the same thing. The *algae* in Basin 1 are what they call the *anabaena*.

Prof. FARLOW.—There are two, and at times three, species, which grow together and are mixed up.

Mr. WIGHTMAN.—They have a sort of a brownish color. The *algae* that appeared in Lake Cochituate are almost exactly the same as was in the Mystic; they are green.

Prof. FARLOW.—They are all green in the beginning. The

brown indicates decay. When they begin to decay they become blue and then brown.

Mr. WIGHTMAN. — There have always been those *algæ* in Lake Cochituate.

WITNESS. — Have they never formed a scum?

Mr. WIGHTMAN. — Yes, they have washed upon the shore, but you would not see them in the form of a scum.

Prof. FARLOW. — That would not be so likely in Lake Cochituate, because the plants would be on the shallow margin. The lake is large enough so that the water is not likely to be still for any length of time, and when the wind blows with any violence the *algæ* would disappear. The size of Lake Cochituate, and the action of the wind, would keep it pretty clear; but in a small pond it would not.

Mr. GREENOUGH. — They tell me that Lake Winnipiseogee has been filled with *algæ*.

Prof. FARLOW. — They have had trouble in Minneapolis in the same way. Just as soon as a city takes pond-water for drinking purposes people begin to pay attention to the peculiar tastes in the water. They have had the same trouble in Minneapolis that we have had. I do not know how bad it is; but Prof. Arthur was appointed to investigate it, and sent on specimens, which are the same as we have with one exception. They all belong to one group of plants.

Q. After you get a pond infested with these things, how are you going to get rid of them?

A. You cannot get rid of them. The only remedy is in the shape of the ponds and the character of the shores. A pond that is shallow will give growth to plants like eel-grass. There is a number of different species botanically related to eel-grass which grow to be several feet long. In shallow ponds they rise to the surface. Just as soon as the water sinks these things stick up above the surface, and all the smaller plants which give rise to bad odors come with them. In case you have in shallow water those plants which in a dry season stand up out of the water, they are like nets to catch the smaller floating forms which then cease to grow and decay. In the Cochituate you do not have these plants for a good many reasons, so you are not likely to have much damage there. Horn pond is very shallow, there is a bar coming very near the surface, and in some places you might walk a good way across the pond. All over the shallow parts of the pond you would have these plants I mentioned as resembling eel-grass, botanically speaking.

Q. What are the conditions most conducive to the growth of these plants?

A. Meadow bottom, loam bottom. I think a loam bottom is the worst. A gravelly bottom is not so likely to be affected by them.

Q. Do they grow upon the bottom?

A. They start from the bottom. These larger plants start from the bottom and shoot up to the top of the water, and stay until late in the season.

Q. They only serve to assist the others?

A. Yes, by collecting the others and lifting them out of the water. If a plant stands up just about an inch above the water, and the water is gradually falling, and there is a scum upon the top of the water, it catches upon the meshes of these plants. This makes the floating plants which form the scum decay, and that affects the water.

Q. The water is sometimes filled with them?

A. Yes, but unless they begin to decay you do not have any noticeable trouble. They do not begin to decay unless exposed to a very bright sun. If you keep the water always high you are not so much troubled by them.

Q. But you might not have the water so full of *algae*?

A. It is not because you have *algae* that you have trouble. You may have *algae* and not have much trouble. If the water is quite covered with scum the chances are you will have trouble. If you have a large body like Cochituate you cannot expect to have much trouble.

Q. The *algae* do not appear spontaneously in water?

A. They have to be brought into it. In case of a new basin that you build, there is a chance that the plants are there in some mud-puddle or ditch, in the marsh which is flooded. In this country the scum-forming plants extend as far west as Minnesota, and, probably, if you examine you would find them farther still. The species we have are not peculiar to this country. They are exactly the same plants they have in Berlin.

Q. It is practically impossible to prepare a basin where these *algae* would not appear?

A. You can prepare a basin so that the bottom shall be much less favorable to the growth of these plants than it otherwise would be.

Q. How do you think a basin should be prepared?

A. It should have a gravelly bottom, if possible. A mud bottom is always bad.

Q. Why?

A. Because, in the first place, the floating forms are not *always* on the surface; they start at the bottom. If you go to Fresh pond at this season of the year, and pull up the weeds, you will find the same scum-forming plants that you find at Framingham. To show my class the scums, I have only to go up there in the fall and pull up these weeds. If it is warm, the small scum-forming plants are on the top. In this cold weather you will find these plants on the bottom, where they are brownish; but they will come up to the surface next spring. If you have a mud bottom these plants are more likely to be there resting among the remains of vegetation. If you have a gravelly bottom these things do not take hold so well; they have to shelter themselves in the refuse of other plants.

Q. They do not grow any more rapidly from being exposed to a hot sun, but only decay?

A. I should say they do not grow more rapidly from being exposed to the hot sun, but they do grow more rapidly when the temperature is raised up to a certain point. They do not increase very rapidly until the July and August temperatures. You gener-

ally find them dormant at other seasons. They flourish better in a high temperature than other plants. They constitute the only group of plants which grows in the hot springs, as those of the West, or almost any other part of the world. There is a certain amount of vegetation on the margins of the springs, and the plants there are much like those you find here. That shows you how likely they are to stand the heat. In spite of that they are killed by the direct rays of the sun, particularly if raised out of water as they are by being washed partly out upon the beach and exposed there.

Q. The effect which shallow fluids would produce, then, would be only that other plants would lift the scum-forming plants out of the water?

A. Yes, sir, and there is another effect. Of course if you have shallow water the scum forms. Suppose a given area to be shallow water, and the scum forms on a large percentage of it, the water does not purify itself so fast from the decayed plants, as it would in a large depth of water. If the bulk of the water is very large you do not feel the same effects as if it were small, even when decay begins. Water purifies itself very quickly. From the time the trouble first came to Horn pond, I watched it, and found that in a fortnight the water became quite clear. I tried experiments in my laboratory, by bringing jars of water filled with the scum plants from Framingham and Fresh pond, shaking them as little as possible. Of course, by transporting the plants, they were somewhat injured; but, except in one case, that slime was almost cleared up in about three weeks. I have had jars of water with scum which I kept without changing the water, and I found that the scum disappeared in three weeks. At the bottom of the jar I found the remains of the plants, some having been entirely killed, and others ready to grow another season. There was still some life left. I kept the jars all winter in my room, and in the spring I found the plants there ready to grow again.

Q. There is, practically, no possibility of our eradicating the *algae* from our basins in any way?

A. All you can do is to let them stand and purify themselves. Or, you can remove the mud and clear the basins.

Q. If you remove the mud, what would prevent the chances of their appearing again?

A. It would diminish the chances of their appearing, but I suppose it would be an expensive job.

Dr. BLAKE.—I suppose the *algae* are affected by shallow flowage and high temperature?

A. Yes, sir. From what I have seen of these plants the model basin should be deep and narrow, and, if possible, with gravelly banks.

Q. Or stone sides?

A. Yes, sir.

Q. And clean bottom?

A. Yes, sir, with even natural sides, and if the water is deep and a steady current flows through it would be very favorable. The worst possible thing is to overflow a marsh. At the time Basin 3

was built there never had been any talk about *algæ* in this country ; and I do not suppose anything was known about them here.

Q. But I suppose we might learn from the mistakes committed in the preparation of the earlier basins ?

A. Yes, I should think the experience was worth something. I am quite certain that a marsh should not be overflowed.

Q. You are quite certain experience shows that the best way to store water is in a basin from which all organic vegetable matter has been removed and to deepen the depth of the water ?

A. Yes, I think that is an important thing, to increase the depth. So far as I recollect, in Basin No. 3 the great trouble comes from the shallow places, the worst being up towards Mr. Temple's house.

Q. To what do you attribute the comparative freedom from *algæ* of Wenham and other lakes ?

A. Wenham is a natural lake ; the water is quite pure from the settling which has come through time, and the original purity of the bottom and cleanness of the banks prevents the growth of vegetation.

Q. And the depth ?

A. Yes. I do not think there is any shallow place along Lake Wenham. It has steep banks, I believe, and that is the model for a pond. In Horn pond you have a sufficient extent of water, but you have shelving banks all round it ; in one place I know it is decidedly shallow ; then you have this nearly bare bottom at one end, possibly a third of the pond, which is nothing more than a shallow puddle, where all sorts of things grow, and where the water sinks to very little depth in the summer.

Q. Have you investigated the storage-basins in other parts of the State ?

A. Not personally. I have had specimens sent me from them. So far as storage-basins are concerned these troublesome plants are as common in remote localities as here. They have the same thing in Central Park, N.Y., particularly in those dirty little streams near the reservoir, and in the reservoir itself. There is a little stream of water passing along under the rocks, just below the reservoir, which I have seen perfectly full of these same plants in the month of June.

Q. We have conditions favorable to these plants in our basins ?

A. Yes, sir.

Mr. GREENOUGH. — Are not the basins in Central Park prepared with much more care than our basins were ?

A. I suppose the basins were all made there with care. There is nothing like eel-grass growing in the reservoir, but there is a little scum evidently washed in from the Croton aqueduct. I do not think you need anticipate any trouble from an artificial reservoir with steep walls and artificial bottom.

Q. Then you would not expect these plants in any artificial basin like the Bradlee basin, at Chestnut Hill ?

A. No, sir. I remember the condition of the land before it was built, and walked over it several times while it was being

built. There is no very good reason for expecting the growth of the plants there, although they might be washed in.

Q. Even if washed in, if they did not find proper conditions for their development, they would not develop much?

A. No, I should not think they would.

Mr. GREENOUGH.—What do these things live on?

A. The nutrition of these plants has not been satisfactorily studied. They have to live on the water itself. They do not get any nourishment directly from the other plants. They are not parasites.

Q. They do not grow in pure water?

A. No, sir; they are more likely to grow in water with a rich organic bottom, and in all probability they must take the organic substance up. They do not grow so well, if at all, in pure water.

Dr. BLAKE.—Would they not grow better in water holding a large amount of solid organic matter in solution?

A. Yes, sir. The more organic matter you have, the more of these plants you will be likely to have.

Q. What is their process of reproduction?

A. They keep budding; the common ones form knobs or buds, and the knobs drop off and keep producing new knobs. One of our common species produces reproductive cells, called spores.

Q. Something like these plants?

A. No, sir. There is something curious about their reproduction. The spores are very heavy and drop to the bottom, where they remain a long time without change. After a while, for months even, they will grow again. A curious thing is that there is a parasite which affects the spores; one year it was very abundant.

Q. Is the parasite, in its decay, inoffensive?

A. Oh, yes; it is a very small thing. A good thing about it is, that the parasite only attacks the spores; it does not attack the other parts of the plant. There are two parasites which are known to attack the species in question. One attacks the vegetative cells, and, of course, it is not of so much consequence; but this one we have attacks the spores themselves. The parasite which attacks the cell, but not the spores, has not yet been seen in this country.

Q. Are these particular *algæ* we suffer from annuals? Do they start, and grow, and decay in a year?

A. They are not annuals in one sense. You may have several crops in one year, and though they eventually sink to the bottom in the autumn, those that sink are not generally the ones that started in the spring. Each budding constitutes one generation, and there are several in one year.

Mr. GREENOUGH.—May one live several years?

A. I should think not. They would bud so rapidly that long before the end of summer the original plants would be separated into a number of new plants.

Dr. BLAKE.—From the taste of the water, and its features during the past summer, do you attribute its disagreeable character mainly to the decay of this plant?

A. During last summer I was away, and did not examine it so

frequently as usual. I only examined it very early in the season, and did not examine it in September or August.

Q. From what you know of the nature and distribution of the plants, would you be willing to say that this was the chief cause of the trouble in the water?

A. I should not say it was the main cause, except in warm weather. I should say it contributed to the trouble.

Q. Of course I have reference now to the disagreeable taste separate from the specific taste due to the decay of the *spongilla*.

A. I think that it is possibly due, in part, to the decay of vegetation. I do not think it is due alone to the plants which produce the pigpen odor. I should say that all decaying vegetation might affect the taste of the water.

Q. What decaying vegetation?

A. Large masses, not exactly leaves, because they decay so slowly, but succulent plants.

Q. And the other varieties of plants which would contribute to the disagreeable taste are also dependent upon the same causes for their growth?

A. The other plants, as I recollect, are nothing more than ordinary water plants, which would not be killed except by some external cause or contamination; for instance, if anything of an unhealthy nature was poured into the water, they would be killed; or, if the water was suddenly lowered, and they stuck up above the surface. In such cases the taste would come only from large quantities of the plants. A very large and sudden decay would cause the taste; but that would be easily recognized if it occurred. I do not think there is any taste that comes from the decay of autumn leaves, except, possibly, a little bitter taste, as they decay very slowly.

Q. But lowering the water and exposing the flats would fairly have a tendency to cause decay of vegetation?

A. Yes, sir. Any sudden decaying would have a tendency to produce trouble from these nostocs or scum plants which produce the pigpen odor.

Mr. GREENOUGH. — I should like to ask you about the Public Garden pond. Have you examined that this fall?

A. Not this fall. I have examined it very carefully before this. It always struck me that there was a great deal of humbug about it. I had been through the Garden and noticed the luxuriant vegetation, and had taken out for my own study, at Cambridge, grasses and plants which I wanted to examine. I read accounts in the papers about there being a sewer fungus in the pond, as if there was a great deal of danger from it, and as if a great deal of it was to be found in the pond. After one of the strongest newspaper notices came to my attention I examined the pond. I do not know what could be meant by the sewer fungus, except, possibly, one species not yet known in this country. The plants growing in that pond show that there could be by no possibility any sewer contamination. If there had been any sewer contamination the plants found there would be quite different from what they are. The plants were abundant, and indicated the pure quality of the water.

Plants are a pretty sure indication of the character of the water. Take some of the mud lands near the Providence R.R., not far from Roxbury. You can tell by the species of plants that grow in hollow places that the water is still brackish, although the hollows are not affected by the tide.

Q. How is it in the pond?

A. In the pond it is perfectly fresh. If there was sewer contamination to any extent these plants could not have grown there. The species of plants which grow there could not have grown there if there had been sewer contamination.

Q. Would *algæ* grow if there is any contamination?

A. No, sir; not the grass-green *algæ*, which are found in the pond. I brought in a pamphlet, this afternoon, about the Berlin trouble. I suppose that, if there is any species which can properly be called the sewer fungus, it must be the species mentioned in that book; but that does not grow in the Public Garden pond. (The professor exhibited the book, and explained the illustrations of specimens of various plants.) This is a common form which grows in sewers, and, possibly, may pass under the general name of sewer fungus; but it is safe to say that very few people in America have heard of it. The plant is microscopic. The best notion you can get of it is from this last plate, which is multiplied by five hundred and forty diameters.

Q. What do you think would remedy the growth of plants in the Public Garden pond?

A. There will always be plants there. The only way is to clean them out, if you have a bottom that you can scrape, and let the laborers go around at different seasons, and rake it so it will be clear for a certain time. No matter what you do there will be some growth there.

Q. Even if the bottom is gravelly?

A. It will be less trouble with a gravelly bottom; but in a pond like that you cannot be sure that it will be free from weeds. I do not believe you can have a crystal lake there; it can be a respectably clean pond, and that is all. Some seasons it will look after itself, but in most seasons it will have to be scraped out. The same plants occur along the Serpentine in London. You will find the same plants along the banks there. But they indicate perfectly pure water.

Q. I suppose, if the bottom was covered with gravel, and the water changed frequently, you would have less trouble?

A. No, changing the water would not affect it at all. The plants that grow in the Public Garden pond are not at all like the ones with which you have trouble in your Water Works. Here is an illustration of the plants. The one in the Public Garden pond is larger than this, but it has the same kind of reproduction. These plants can be brought in at any time by the fresh water that comes into the pond.

Q. The water being stagnant would increase the quantity of vegetation?

A. We have different species, dependent upon the rapidity of water; they may be large plants in rapid water; where you have

stagnant water you will have other things; you will have more undesirable plants, which would be likely to belong to the nostoc family. There are no nostocs in the Public Garden, or merely traces of them.

Q. There was an appearance in the pond last summer as if green paint had been thrown into it. Would that produce this trouble?

A. If it died it would. If it grows up toward the edge, and the water falls off, it will die.

Q. The only advantage in letting off the water would be to clean it out and start afresh?

A. Yes, sir. Water which is perfectly clear to the eye contains germs of plants. When wash bottles, used in my laboratory, are filled, perfectly clear water is used; yet in a few weeks a green growth is found on the bottom of the bottles and they have to be cleaned with alcohol or some stronger reagent.

Dr. BLAKE. — Would any decided advantage follow from repeated raking of the storage-basins?

A. I should think it would. I should think it would be a benefit to Horn pond by taking off the plants. There is a practical difficulty in raking plants which are two or three feet high, but they should be cut down.

Q. Then you would advise the removal of the projecting substances?

A. Yes, those which come near the surface and above it.

Q. So, if the water was drawn down in summer by reason of requiring its use in the city, and there had been a large amount of the margin exposed, you think the removal of the loam and taking off of the matter would tend to lessen the amount of those plants?

A. Yes, I think so. They have practically tried removing the plants in Cambridge with a very good result. You may know that the *anacharis*, a plant like eel-grass, grows there. It has overrun all the water-courses there. It is in Fresh pond, and men are working all the time cleaning it up, and are constantly going around the pond from one place to another. It is thrown on the shore in great heaps; but the quality of the Cambridge water is good. I have been surprised to find that it has such good quality, because we have the *clathrocystis* and other scum plants there, and I am able to get enough specimens for my own class easily. But I am inclined to think it is owing to the cleaning out of the pond so often that the water is not bad.

Q. You are decidedly of opinion that a marked improvement would follow such a course in the storage-basins of Boston?

A. I think it would if the work were thoroughly done. In the case of the Public Garden pond I am at loss to know what the cause of the trouble can be. The sewer fungus — meaning the Berlin plant — I am satisfied does not exist. If that plant was there to any extent you could easily distinguish it. Cementing the bottom will not prevent a growth of plants. A gentleman in the vicinity of Boston had an artificial pond where the water was tolerably clear. He wanted to improve it, and cemented the whole

bottom ; but plants began to grow, and he was obliged to clean it at intervals. It was thoroughly cemented ; but these plants attach themselves to the bottom and grow there. If there is a deposit upon the bottom, it takes but very little earth to start the plants. The advantage of cementing is that you can scrape off what is on it.

Mr. SHEPARD.—Do you think any advantage would come to the city from repeated observations made of the water for a long space of time, as to its temperature, its color, its taste, and the kind and quantity of life in it?

A. Yes, I think there would be. But that is a thing from which nothing directly of advantage could be *promised*. It is on the general principle that if you can know thoroughly the habits of these things, you will undoubtedly be able to know more about the means of removing them. But it is only in a general way. It would not do to promise any City Government, that, after so much has been spent for scientific investigation, such and such results would be reached.

Q. As an expert would you feel like recommending such a thing to be done?

A. As an expert I should like very much to see it done. You see the indefiniteness of the result which you are able to promise in dealing with the City Government. It is a thing for a corporation to do, by the employment of a scientific man connected with a university, where there is a laboratory for research. I do not see, however, why the persons employed on the Water Works—certainly those I am conversant with—are not competent to make valuable observations about temperature, and all other matters, except minute details of animal and vegetable life.

Q. Without speaking in the interest of science, but simply for the quality of water, and the improvement of the water supply, is it a thing that, in your opinion, ought to be done?

A. It is a matter where dollars and cents should come in. I do not think the city would certainly be able to save money by the operation. It might and it might not. It probably would ; but it is a matter of uncertainty, you see.

The CHAIRMAN.—Would they not in that way come to find out some method of stopping this trouble?

A. I think very likely they would.

Q. That would be the object of the investigation, I suppose?

A. If the City Government appropriates the money for the investigation, of course it would have to extend over a certain number of years before anything definite could be done, and it would be in the hope that, in some way or other, the city would be able to save just so much money. But we could not absolutely promise it ; but the probability is there would be a gain.

Mr. SHEPARD.—I understand that ; you speak very guardedly ; but yet it is something you think much good would be likely to follow from ?

A. Yes ; but in order to secure good results it would have to continue, not for one year from now, but for a series of years, with constant observations.

Q. You noticed that my question related to repeated observations for several months. Perhaps several months was too short.

A. I do not think anything would be accomplished in less than three years.

Dr. BLAKE. — But after three years we should, under a competent investigator, learn the natural history of these plants and the sources of their growth, and that would lead us, of course, to fully understand the methods for their removal?

A. Yes, I think so. To illustrate: there is one point that has never been settled, and I suppose it would have to be settled: the way these plants have of sinking and rising. The engineer, Mr. Fteley, says the scum plants sink suddenly and rise again suddenly. I was inclined to think they did not sink, but I am now inclined to think they do; but why should they sink? To know why these things should go to the bottom when exposed, and why not go to the bottom when not exposed to certain atmospheric conditions, that is the point. Another example of the points to be settled is, how do these things live, and do they require an excess of organic matter?

Q. Inasmuch as you do not find them growing in the same state of luxuriosness in a water free from organic matter, I think it is fair to concede that that is essential to their growth?

A. Yes, sir; but one should show just why the organic matter is needed.

Mr. GREENOUGH. — Basins 2 and 3 were prepared practically in the same way, yet Basin No. 3 is filled with these things, and Basin No. 2 is not.

A. I do not know the position of Basin No. 2.

Mr. GREENOUGH. — It is on the other branch of the river, and there never have been any *algæ* seen there. Is not that true, Mr. Wightman?

Mr. WIGHTMAN. — Yes, sir, it has never been so as to be noticeable.

Prof. FARLOW. — When I have been to the basin it has been when *algæ* were there, and nobody has spoken about Basin No. 2.

Mr. GREENOUGH. — Basin No. 2 has a mud bottom and sides which are exposed in summer.

Prof. FARLOW. — What is its position in regard to Basin No. 3? Does Basin No. 3 lead into it?

Mr. GREENOUGH. — No; they are on two different branches of the river. Basin No. 1 is between them, the river comes down and Basin No. 1 is on the apex of the fork.

A. I have never been there to see the shape of the basin.

Q. The only difference is that there is a much larger flow of water through Basin No. 2.

A. That is a very important element. Is it not a deeper basin?

Q. I believe it is not so deep. But there are probably more flats exposed in Basin No. 3 than in No. 2.

A. It struck me that in Basin No. 3 there is a large amount of flats exposed. In the centre it is comparatively deep, but on the south side there is a large exposure of flats.

Mr. WIGHTMAN. — Basin No. 2 has 23 per cent. of shallow flow-

age and Basin No. 3 has 27 per cent. of water less than five feet deep. There is a very small difference in the amount of what we call shallow flowage.

Dr. BLAKE.—All the land is of the same general character as Basin No. 3?

Mr. WIGHTMAN.—Yes, the same.

Dr. BLAKE.—And the basin was not more thoroughly prepared?

Mr. WIGHTMAN.—Yes, sir.

Mr. SHEPARD.—This shows how hard it is to give an opinion until we get at the facts.

Prof. FARLOW.—Yes, it is much easier to get specimens than facts.

Mr. WIGHTMAN.—The shallows and places where these *algæ* will grow are quite as numerous in Basin No. 2 as they are in Basin No. 3.

Prof. FARLOW.—Basin No. 3 is bad; but it is nothing like as bad as stated by persons at Framingham. The stories told of injuries done are perfectly preposterous. The belief that special diseases have been produced by the growth of the germs in the Water Works is quite unwarranted.

Mr. GREENOUGH.—Do you know anything about the *spongilla*; or is not that in your line?

A. No, sir, I know the *spongilla* by sight, so that in examining the water I recognize it.

Dr. BLAKE.—I suppose that even so small a matter as the motion of the water would influence the growth of this *nostoc*?

A. Yes, sir.

Q. So if you have a strong current in Basin No. 2, and the water is changed more frequently, it would help to explain this difference in regard to *algæ* in the two basins?

A. Yes, sir; I also think that if Basin No. 2 is swept by the wind the water would not be so apt to be still, and the scum would disappear.

Mr. GREENOUGH.—The more quiet the water the more it would grow.

A. Yes, sir, the wind would break it up. If I want to get any specimens in Cambridge I have to take a still day. When the wind blows I cannot get any.

The Commission held a further conference with City Solicitor Bailey in regard to the laws relating to protection of water supplies, and adjourned subject to the call of the Chairman.

TWELFTH HEARING.

BOSTON, December 27, 1882.

The Commission met at 4 P.M. and held a conference with E. P. Nettleton in regard to the laws to prevent the pollution of water supplies.

Adjourned for one week.

THIRTEENTH HEARING.

WEDNESDAY, January 3, 1883.

The Commission met at 4 P.M., Alderman Caldwell, chairman, presiding.

STATEMENT OF MAJOR GEORGE W. DRESSER.

Mr. GREENOUGH.— Major, you were in the employ of the Croton Water Department of New York City for some time?

A. Yes, sir, for several years; I think about four years.

Q. In what capacity?

A. As assistant to the chief engineer.

Q. Are you familiar with the accumulation and storage of the waters of the Croton river?

A. Yes, sir.

Q. Will you show us on the map here where the Croton river runs and where the reservoirs are located?

[Witness explained the course of the Croton river from its source in Putnam county, N.Y., toward the Hudson river, and pointed out the locations, as near as possible, of the reservoirs for storage.]

A. About eight miles from the village of Sing-Sing there is a dam across the Croton river which forms what is known as Croton lake. From that the main aqueduct coming to New York City takes the water as far as High bridge. The river extends up into the eastern portion of the State into Putnam county, where it divides into several branches going up into the mountains. Across some of those branches have been built dams, to form what are known as the storage-reservoirs, the idea being to keep these reservoirs full, and when the water gets low in the river, so that the amount running to the Croton dam is not sufficient to supply the demands of the aqueduct, then these storage-reservoirs are opened to reinforce the river in a dry time. There are other dams, which have been projected and contemplated, which have not yet been built.

The CHAIRMAN.— Do these reservoirs empty right into the river?

A. Yes, sir. These reservoirs are formed by constructing dams across the valley, and they simply hold the water in reserve. As the water comes into them it overflows through the waste weirs. In the preparation of these reservoirs the ordinary method is to

simply clear the ground — what is known as grubbing and clearing, in a general way — and then let the water in and fill the basin. The ordinary practice, I think, is to fill the reservoir two or three times and then let the water go ; and they consider it safe to hold it. But the water, after it leaves the storage-reservoir, runs in the open river until it gets to the Croton dam, twenty miles below, probably ; and, of course, all that time it is being tumbled over and aerated, and it is very different from what it would be if taken from the reservoirs and turned into the system of distributing pipes. The Croton water-shed is four hundred square miles in area. Upon the supposition that you are able to save fifty per cent. of the waterfall, that would give them four hundred millions of gallons a day as the average available product from the water-shed. They are running into the city of New York to-day about one hundred millions of gallons, and when they talk about an inexhaustible supply, the fact is they are using about twenty-five per cent. of all the supply they can get from that source. There is very little trouble with the water in New York from taste or any bad smell, or anything of that kind. Occasionally we used to have trouble in the spring of the year, when the first warm days came on ; what we call the cucumber taste, in the water ; it always occurred first at points where there were dead ends in the pipes, for lack of circulation. This was remedied by opening the hydrants in the streets and blowing out the water and clearing the pipes, — getting rid of the stagnant water. Then we would not have any more trouble, as a general rule, until some time in the autumn, when we had warm days and cool days. But circulation is the great thing. The taking of the water from those reservoirs, and its tumbling over as it runs down the river, causes it to be aerated. In the same way they avail themselves of that same thing as far as possible in the supply in London, where they pump their water from the river to the reservoirs along the sides of the river, which are the filtering-basins. The water is made to come up into the air like a fountain, and rolls over and becomes oxygenated. Then it goes into the filtering-beds and is filtered and delivered from there into the city. These filtering-beds have to be constantly changed ; you can see them any day as you go along on the railroads. They are emptied, and you will see men carrying out a lot of gravel, and another lot of men bringing in fresh gravel. This is necessary to get the water clear for use. The water is frequently examined by examiners, who analyze it regularly, — so many times in a quarter or a month ; but they are quite successful in getting water that is reasonably pure and available for domestic use by simply filtering through gravel.

Mr. GREENOUGH. — Do you know anything, Major, about the New York State law in regard to protecting the purity of the water supply?

A. Yes, sir ; there is a very strict law against flowing anything into the Croton river or reservoir that would be injurious to the water. We had some cases where we prosecuted people for letting dead horses and contaminating things get upon the banks of the stream. The department always had inspectors to watch for that.

Q. The law is very short and very strong?

A. Yes, I understand it is a very strict law. They have very little trouble with the water in New York so far as bad taste or smell or anything of that kind.

The CHAIRMAN.—Do you ever succeed in getting convictions for these offences?

A. Oh, yes. It is in the country, and the territory is very different from what a thickly populated district would be.

Q. Is it left to a sheriff's jury for trial, or how is the law enforced?

A. It comes before the ordinary county court, I believe.

Mr. GREENOUGH.—I saw a copy of the law the other day. The engineer of the Croton works told me that when there was a nuisance they went and smashed the thing up and let the parties sue the city of New York. They put the *onus provendi* on the other side.

Dr. BLAKE.—In the preparation of your basins you necessarily have a large quantity of shallow flowage?

A. Well, that depends upon the formation of the ground. At Boyd's corner there is comparatively little shallow flowage; the hills are quite steep, and are mostly occupied as sides for the reservoirs. In one reservoir on the eastern branch of the river there was more of shallow flowage than there is on the other.

Q. Are you familiar with the margins of the storage-basins?

A. I could not say I am familiar with the margins of the basins on the eastern branch, because they have been flooded since I left the department.

Q. In the basins with which you are familiar, have you noticed a rich growth of *algæ* during the hot weather along the margins?

A. No, I do not think they have had any trouble of that kind. We sometimes have a green scum formed right in the city reservoirs.

Q. Do you think the absence of this growth of *algæ* is due to the depth of the water which you have in your storage-reservoirs?

A. No, I do not know as it could be attributed to that entirely. I think there is a great benefit to the water from its having a long distance to flow in the natural bed of the river. I think that is the whole secret of it.

Q. You might get rid of a certain flavor and color by thoroughly oxygenating or aerating the water by means of the motion in its exposure to the air; would you expect to get rid of the taste of mineral water by that process?

A. Well, I could not say positively; but water certainly purifies itself rapidly as it runs along the river. There is no question about that.

Q. But would you expect water to get rid of decayed vegetable matter which it held in solution?

A. Certainly.

Q. What is the process?

A. By depositing it.

Q. But it cannot deposit it while in motion.

A. But the motion is always changing in velocity, and every change of velocity has a tendency to deposit whatever is held in suspension.

Q. Would it not be more likely, if perfectly quiet, to deposit anything it held in solution or suspension?

A. If it was not flowing at all?

Q. Yes.

A. Well, it might. But you take a running stream, and there is a frequent change in the velocity, and each check in velocity causes deposits. That has been shown in the experiments on the Mississippi river where the deposited matter is held in suspension.

Q. But when the water holds mud or clay, it is in suspension, and not in solution. Now, what we want to get at is this : whether it is your opinion that when water dissolves decayed vegetable matter — *algae* or matter of any kind which it takes up in shallow flowage — that it would clear itself of that by this process of motion that you speak of?

A. I think it would if time enough was allowed.

Q. Do you know anything about the analyses of Croton water, how many parts of solid matter it contains?

A. I do not remember the figures, but I think the Croton water stands well up on the list for purity.

Q. Have any measures been taken of late years to protect it from contamination or pollution?

A. Nothing more than the ordinary measures I spoke of in the construction of the reservoirs.

Q. In the early history of the Croton Water Works complaints were very numerous and decided as to its bad quality?

A. Well, the analyses that have been made from time to time since do not seem to show it to be very bad water. It stands, I think, about fourth or fifth.

Q. In constructing these dams across the arms or tributaries of the river, of course you expect the water will overflow the banks of the tributaries, do you not?

A. Yes, sir.

Q. And flood the land on each side in the reservoir?

A. Yes, sir.

Q. Did you build dykes on each side of the stream to hold the water?

A. No, sir, we just flood the land on each side. I think the dam at Boyd's Corner is something like sixty to seventy feet high.

Q. That allows the water to flow upon the banks on each side for a great distance?

A. Yes, sir.

Q. Have you taken any special pains to prepare the land adjacent?

A. No, sir, nothing special, except what we call grubbing and clearing, which I have already spoken of.

Q. Before New York City took the land now used for storage purposes was it used for agricultural purposes?

A. Yes, I think so. Part of it might have been woodland ; but the entire Croton basin is agricultural land ; a good deal of it used for grazing, and for milk farms.

Q. Does the city of New York own the land along the margins of these basins and control it to any extent?

A. No, sir, it has bought the land flowed ; that is all.

Q. So that people living in the neighborhood drain, as it were, into the basins,—do they?

A. The ordinary rainfall comes down on the hills, and comes in the streams into the basins. That is the way the storage-basins are filled,—from the streams.

Q. Do you take any measures to prevent drainage from the houses into the reservoirs?

A. Oh, no.

Q. And from the dairies and manufactories?

A. Well, there are no manufactories up there, I believe. It is an agricultural country. The ordinary drainage from a farm-house would be purified after passing through the soil.

Q. Are there any rivulets or brooks that run into these storage-basins that are subject to such contamination?

A. I do not think there are any. I do not know of any. It is a sparsely settled country.

Q. So, under the circumstances, the amount of house-drainage is small in quantity?

A. Oh, anything of that kind would be insignificant when compared to the amount of water. If there was anything of that kind, the city would acquire it and abolish it.

Q. Are you familiar with the source of the Boston water supply?

A. Not specially. I have passed by Lake Cochituate, at Framingham, a great many times in the course of my life, but I know nothing about the Sudbury-river supply, and never examined it.

Q. If you had evidence that the sewage of a part of a town was running into your water supply, do you think the law of New York would be effective in preventing it?

A. Yes, sir.

Q. And you know of such action having been successfully taken?

A. No, I do not think there has been a case of that kind where the sewage from a town contaminated the water. If a farmer had a horse die, and he carted him out on the banks of the river, the officers of the Water Works would make him remove it and take it away, because, although the actual damage from it would be very small, still, if anybody should come along and see the dead horse floating in the Croton lake, it would make a great hue-and-cry. It is very easy to excite the public mind in regard to the water supply.

Q. Then you, as an engineer, are satisfied that the city of New York takes care to protect its water supply properly?

A. Yes, sir. It is the business of the Croton Department to furnish a supply of "pure and wholesome water."

Q. And you have been aided by the law to accomplish that object?

A. Yes, sir. The law authorizing the construction of the works contained a provision—it was passed at that time or soon after—giving the authorities power to protect this stream from contamination. Such a provision is absolutely necessary.

Q. As an engineer, what measures do you consider necessary in the preparation of storage-basins?

A. That would depend altogether upon the circumstances of

each particular case. If your storage-basin was in a thickly populated district, why, of course you must prevent anything but pure water, which you supply to people, from coming into it; you must cut off all contaminating sources, and you want to have your basins arranged in such a way that if it is necessary they can be cleaned from time to time. The reservoir at Forty-second street, in New York, is what is known as a disturbing reservoir, and it is also to a certain extent a settling-basin, because the water comes into it and passes out. It is built of masonry entirely, and its sides are of masonry. I saw one half of it emptied once for the purpose of making some repairs. I think it had been in use twenty years, and I do not think there were six inches of mud in the water.

Q. You are in favor, then, of periodical cleaning of the basins?

A. I think the basins within a city should be. For instance, your storage-basins may be constructed in such a way that they are divided by masonry wall, and you have practically two basins, and you can, if necessary, from time to time, exhaust one, and see that it is perfectly clean, and there is no trouble about it. Then, too, that is a good prevention against accident. You do not have all your eggs in one basket, to use a popular phrase. A large reservoir may be divided by a central wall which comes to within five or six feet of the top, so that, if there is a break on one side, you are not deprived entirely of a supply of water.

Q. You think a city should have a sufficiently large number of storage-basins to allow periodical cleaning?

A. Unquestionably.

Q. Do you consider that periodical cleaning of the basin is absolutely essential to the purity of the water?

A. I do not know as it would be absolutely essential.

Q. Well, beneficial?

A. Yes, sir. When you say absolutely essential, that is a strong expression.

Q. If you found in those storage-basins that the proportion of solid matter was above what chemists consider good for health, you would consider it necessary to remove any decaying vegetable matter?

A. Yes, sir. I believe there is great virtue in the running of water in open streams. Some experiments were made recently,—I do not know whether you saw them or not,—by examinations of the water in the river Seine, and the effect of sewage going through there. The result of those investigations certainly went to prove that water purifies itself very rapidly.

Dr. BLAKE.—I want to ask if you agree with the following (reading from *Boston Medical and Surgical Journal*, Dec. 21, 1882, Pro. Suff. Dist. Med. Soc., of Oct. 28, 1882):—

Dr. A. N. Blodgett said that he could testify to the filthy condition of the basins, as on two occasions he had been in the neighborhood of Farm pond when the water had been drawn off, and they had the appearance of flats at low tide filled with decaying vegetable material, like fresh-water swamps, and certainly would lead one to suppose that they contained everything considered injurious to health. The area exposed was quite large, and the water must be distributed daily in the city.

If you had a condition like that in the Croton water supply, you would consider it necessary to clean the basin, would you not?

A. That would depend upon where that basin was situated. If it was at the head water, up in the hills, where the water had some twenty or thirty miles to run before it came into the Croton lake, I do not think it would be so important a matter.

Q. But if that water entered directly into the conduit?

A. It would certainly be an advantage to the water if that basin was kept perfectly pure and clean; there is no doubt about that.

Q. And if physicians told you they thought disease had followed the use of that water, that would emphasize your opinion as to the necessity of cleaning the basin, would it not?

A. I do not think it would.

Q. Well, as an engineer, you would be satisfied that the conditions called for cleaning?

A. Yes. But physicians are very much like other professional men; they are apt to have special hobbies, just as engineers have, and feel that they must have a cause for something.

Q. But if physicians found by chemical analysis that the water contained 30 to 45 or 50 or 70 parts of solid matter, that would corroborate their view?

A. Yes, sir; I think that in cases where the supply is a limited one you can very often trace the origin of the disease.

Q. The point of this testimony bears strongly upon the contamination of Lake Cochituate from Pegan brook, where the sewage from two thousand inhabitants runs into our water supply.

A. And it ought to be shut out.

Q. The law in our State requires that we shall be able to demonstrate the impurity of the water at the point where the city takes it, which at present is chemically impossible; nevertheless, all scientific men are pretty well agreed that the danger exists, although we may be unable to demonstrate the fact by conclusive evidence.

A. There is no question but there must be danger from the influx of a stream like the one you speak of.

Q. We feel that the water containing the sewage of a town conveys disease, and it is simply a chance of those disease germs finding their proper source in this contamination.

A. There is no question but it will contaminate your water, and this will increase with the increase of population on the stream; but by going a little further up the stream cannot you get evidence of pollution?

Q. There is no difficulty about it. We have seen the drainage from a large hotel emptying into it.

A. I mean by analysis.

Q. The stream is filthy to look at.

A. Why cannot you prove it?

Mr. GREENOUGH.—We can prove it goes into the lake, but we cannot prove by analysis that the water is any worse where the city takes it, at the other end of the lake, than it would be if this contamination did not flow into the lake.

A. But the city must be considered as taking the water of that

special stream at the point where it enters the lake, and your law ought to enable you to deal with it at that point in a most summary manner. The law cannot be made too stringent for the protection of a city's water supply.

Adjourned to Wednesday, January 10, at 4 P.M.

FOURTEENTH HEARING.

WEDNESDAY, January 10, 1883.

The Commission met at 4 P.M. All present.

STATEMENT OF JOSEPH P. DAVIS, EX-CITY ENGINEER OF THE CITY OF BOSTON.

The CHAIRMAN.—Mr Davis, the Commission want to know what are your ideas in regard to the method of constructing our reservoirs and the pollution of our water supply. You are pretty well acquainted with the situation of the Sudbury river and all the other streams. Please give us your ideas, in a general way, and the Commission will ask any questions which occur to the members.

A. Since I have left Boston you have had some special trouble with the water, which, of course, I know nothing about, except what I have seen in print. I refer to the cucumber taste which Prof. Remsen discovered the cause of. I have understood an attempt has been made to connect that with the soil in the basins; but I do not think there is any connection between them. That is an impurity which occurs in all surface-waters, and in natural lakes to some extent. Even at Poughkeepsie, which takes its supply from the Hudson river, when the temperature of the water gets up to about 70 they have similar trouble. As you will see by an extract from a Baltimore paper, which I just handed to Mr. Greenough, they have recently had similar trouble there. I never have seen the Baltimore water works; but I understand that they take water from what is known as the Gunpowder river,—that they put a dam across it, and brought the water into the city in a way very similar to that in which the Sudbury-river water is brought into Boston. But the ground which is overflowed to form the storage-basin is not farming land,—it is almost all rock,—and yet they have, apparently, the same trouble which you have here.

MR. GREENOUGH.—You were the engineer of the city at the time the three basins on the Sudbury river were constructed?

A. Yes, sir.

Q. How far, in your judgment, should the Water Board have gone beyond what they did in taking out the soil from those basins?

A. I will tell you about that, as far as I can remember. There was no definite action taken by the Water Board. To have taken the soil out of the basins entirely—not including the muck, but simply that which you would call soil—would have caused a very large expense. It would probably have cost six or seven hun-

dred dollars an acre, and there are between five and six hundred acres in that territory. That never was contemplated. If you will refer to the report of 1873, you will see that the question was discussed there. In the original estimate there was an allowance of \$75,000, if I remember rightly, for taking soil out of the basins, only \$15,000 or \$20,000 of which was spent. This was not due to opposition of the Water Board. If I had thought it was necessary to have had it spent, I think the Water Board would have given the necessary authority. That which we wanted specially to remove was in the upper part of Basin No. 2, which is the one you have had the least trouble with. Basin 3 was considered to be the best basin by far, — first, because the water of Stony brook was very pure and less polluted in every way; and, second, because it was very much deeper, and had bold shores, — and yet that is the one in which there has been the most trouble. One of the reasons for not spending it was this: If you remember, after the supply was taken, there was a delay of two years in discussion in the City Government before we were allowed to go on. The city got into a very critical condition as to its supply before the City Council finally passed the order authorizing the Water Board to take the water of the river and complete the works, which had been begun two years before. After we were authorized to go on, we had to get the dams built as soon as possible. The foundations were built by days' labor, and we employed from three hundred to four hundred men on them. I should think that was as many men as could be well handled at that place. To have undertaken to strip the soil from those basins with anything like thoroughness would have required the employment of a very large body of men, which could not have been very well handled there while the other work was in progress. We made some excavations in the upper part of Basin 1 to ascertain the cost and see what the general effect would be; but, after viewing them, I concluded, all things considered, it would not be a judicious expenditure of money. I refer now to the time when the basins were under construction. Later (in 1879), when soil was wanted for the Back Bay park, I urged the removal of portions of the soil from the basins.

Q. In other words, the Water Board authorized you to go ahead and expend the \$75,000 appropriated for removing the loam; and so far as any responsibility remains for not taking out the loam, that belongs to you and not to the Water Board?

A. I do not think that the Water Board authorized me to spend the money; but would have done so if requested. In my judgment, at that time, the expenditure would not have been judicious. Unless you were going to spend an enormous sum there, in other words, take out *all* the soil, I thought it would not be of much use to spend \$75,000. I do not want you to understand that an appropriation was made for that purpose. The City Government made an appropriation each year without stating exactly for what purpose it was to be spent, and in the original estimate was \$75,000 for removing this soil.

Mr. SHEPARD. — Suppose you had not felt at that time there was great need of water in the city, and you had had as much time

as you needed, would you have spent any part of the money in removing the soil?

A. I should not have spent much. There are many places in the basins which could be cleaned out. I supposed that the Water Board would, and presume that they now have a force of men up there cleaning, when the basins are drawn down, the shallow places where the waves agitate the soil and where plants would be likely to grow. Instead of removing the soil from the upper part of Basin 2, we built a dam, so that the water would not be drawn down there so low as in other parts of the basin.

Mr. GREENOUGH. — You consider the water in it not so good as in Basin 3?

A. It was so thought then, — that Basin 2 would not be so good as Basin 3.

Q. If you had removed the loam from about the shores of these basins, it would simply have been to prevent the growth of these plants when the water was drawn down?

A. Yes; and prevent the waves from stirring it up. When the soil is once mixed with the water it takes a long while to settle out.

Q. Did you not remove the loam from the banks at all?

A. No, at least to no great extent. It was generally pasture land on the shores, along the water-line; the deep soil was in the bottom of the valley.

Q. So what you did was practically to build the dam, cut out the trees, and turn the water in?

A. That is practically it. We cleaned the shore line to some extent.

Q. Suppose you were going to build those basins over again, with the experience we have had, what would you do?

A. If you throw the park question out entirely, and say only that you wanted the soil removed on account of the water, not being aware that its presence produces any serious effects, I should not take it out. I reported strongly in favor of taking the soil out, as it was needed for park purposes; but, without that, I should not take it out.

Q. None of it?

A. Except in the shallow places of which I have spoken.

Q. Did you not consider that the soil in the shallow places was likely to damage the water?

A. Yes, sir; but I did not think it worth while to spend two or three hundred thousand dollars to take it out. I would like to call your attention to the original report upon that very question.

Mr. BRADLEE. — I suppose that at that time you did not imagine the water would be required to be used so quick?

A. Yes; that was the point. That is where the whole thing has turned. As you will see in the report, it was supposed that the Sudbury-river water would be used only for a certain number of months in each year, — that there would be some attempt on the part of the city to restrain the use of water. In the first place we were not allowed to commence building the works until something like two years from the time we expected to commence them.

Q. If you had expected to use the water in those basins at once, would you have ordered them stripped?

A. It is difficult to say at this time what I would have done some years ago. I might have stripped the soil down to seven or eight feet below the high-water line had I known that the full capacity of the basins would be required at the outset. It has been necessary to draw the water level down several feet each summer, thus exposing to the air and sun large areas of the unstripped surfaces. Speaking of these basins, the original report says (reading City Doc. 29, of 1873, pp. 34 and 35) :—

To secure the estimated supply of forty million gallons per day, seven new storage reservoirs or basins are required, as has been before demonstrated. It will be many years before such a supply is needed. For a while the Sudbury water will be used for short periods in each year only, to tide over the times when there is a deficiency or some temporary impurity in the Cochituate supply.

It is proposed to build now the three lower basins, marked I., II., and III., on the plan, and leave the others to be constructed as they shall be wanted. These three basins have, in connection with Farm pond, a storage capacity of 273,000,000 cubic feet, and are adequate for a daily supply of about twenty million gallons. So large a capacity is not needed at first, but the position of the reservoirs is such as to require that they all be constructed at one time, and, moreover, they are necessary for the proper *purification* of the water, no matter how small may be the supply used.

The Whitehall reservoir is already built, and would require but a small expenditure for work to place it in a serviceable condition. Whether the city should now take possession of it, or wait till its use becomes indispensable, is a question that involves a variety of points, some of which do not come within the engineer's province to decide.

On account of the value of the land flowed, and other private interests destroyed, the character and magnitude of the dams required, and the cost of raising and protecting town-roads, and railroads, the cost of Basins Nos. I., II., and III., will be comparatively large. Basin II. flows out two mill privileges of considerable value. No. III. includes within its boundary an extensive swamp now covered with a heavy growth of wood, and they all flow large tracts of meadow-land, supporting a rich vegetation which it is desirable to have removed by grubbing and excavation, as it will otherwise have to be gotten rid of by decomposition. The cost of this class of work will, however, be so great as to limit its application to small areas where the most benefit will be produced, such as that in the upper part of Basin No. II. The vegetable matter upon other tracts must await the slower processes of chemical change, in undergoing which it will be apt, at first (especially in the summer months), to deteriorate the water.

This action will in part or wholly cease after a while, and the basins will slowly assume the character of natural ponds and lakes. As it is desirable that such conditions shall prevail before the city is largely dependent upon the Sudbury water for its supply, it is important that the construction of the basins be commenced at an early day. It will probably require three seasons, at the best, to put them in readiness for use.

Mr. SHEPARD. — How long, in your opinion, does it require before the basins will be in the condition of natural ponds?

A. What was meant by that expression was, that the shore lines, the parts that form the slopes of the shores, would become clean gravel. That is caused by the beating of the waves on the shore and washing the soil down the slopes. I have not been out on the basins for three years or more; but I should think that that action must have already taken place to a great extent. I suppose Mr. Wightman knows about that.

Mr. WIGHTMAN. — Where the slope is steep it takes place in about two years ; but where it is flat it takes longer. Basin 2 is practically in that condition now.

Mr. DAVIS. — The whole theory at that time, when this report was made, was that the city had, in Lake Cochituate, almost the quantity of water it needed, and that we had plenty of time to build the Sudbury works and let nature take care of this question of soil. If I had known to what extent those basins were to be used, it is possible that I would have had the slopes stripped of the soil. But, to prevent the water from taking up organic matter in the basins, the soil should be taken from the valley bottom itself. In other words, it meant railroad work, — laying tracks and putting on cars and engines. We could not have got horses and carts enough to get it out in any reasonable time. It involved the doing of this work besides the building of the dams, and would have delayed the work upon them.

Mr. GREENOUGH. — You did not think it of enough importance to go on with?

A. No, sir ; and I do not now think that the city of Boston would be justified in spending the amount of money that would be required to take the bottom soil out, except in so far as it is needed for use on the parks. It could be better expended in other directions.

Mr. SHEPARD. — Then it is the expense that you look at?

A. Yes, sir. I do not think the quality of your water would be enough improved to pay for that expense.

Mr. GREENOUGH. — Supposing that experiments showed that the water which came into those basins took up a very considerable quantity of vegetable matter and held it in solution, how would you expect to avoid that except by taking the soil from your basins, so as to render the water not deleterious to health?

A. I do not know that experiments have proved your last proposition.

Q. Well, all the chemical evidence we have had here has been to that effect. All the medical societies here in Boston have memorialized us to the effect that the water is not in a good condition for health.

A. I do not know any facts to show that the presence of the soil is deleterious to health. If it is dangerous to health, the expenditure would be justified. Deleterious has various shades of meaning. If it is dangerous to health you are justified in spending any amount of money to take it out. But I do not know of any evidence that will go to prove that.

Dr. BLAKE. — If you found the water inside the dam containing a very much larger number of parts of solid matter in solution than is good for the health of those who drink it, and that it would be likely to affect health in hot weather, what would you say to that? If medical testimony concurred in the expression of that opinion, — that the using of water containing a large amount of solid matter in hot weather, at a time when such diseases as diarrhoea, irritation of the bowels, etc., prevailed in the city — what would you say to that?

A. Will you allow me to ask a question before I answer that?

Q. Certainly.

A. I think I know of the series of experiments you refer to, and you will see that in the 1873 report I stated that the water in the basins is going to take up a great deal of organic matter. But in order to arrive at a solution of the question I should want to know what is the quality of the water when it enters the pipes here in the city. It is turned into a conduit from the river, thence taken to Chestnut-hill reservoir or the Brookline reservoir, and there allowed to settle. The comparison should be between the water before it is allowed to enter those basins and as it is delivered in the city.

Q. But in passing it is not exposed to the air.

A. It is not exposed to the sunlight, but is exposed to the air. The conduit is not run more than half full.

Dr. BLAKE. — But it is not oxygenated, and consequently it is deprived of the beneficial effect of close communication with the air.

Mr. GREENOUGH. — Those experiments made by Prof. Wood were with water taken from the basins and from faucets here in the city, were they not?

Mr. DAVIS. — There were some analyses of that kind made at the time when we were turning the water into Lake Cochituate in 1872. The water of Sudbury river showed a quite large proportion of organic matter, and the water of Lake Cochituate was shown to be in a much purer condition. (See City Doc. No. 29, 1873, page 32.) I have no doubt it cannot be otherwise than that water poured into those basins would take up a good deal of organic matter.

Dr. BLAKE. — By excavating the basins, would you not avoid that additional amount of organic matter?

A. Yes, sir.

Q. Well, do you not consider that the avoidance of a source of pollution of that kind would justify a reasonable expense, particularly where you have this annual clamor in hot weather as to the disagreeable condition of the water?

A. Well, at that time we had no such question to decide. The clamor had not come, and we did not anticipate anything like the trouble that has occurred. We did not expect this growth of *algæ* or this cucumber taste. I do not think the soil has anything whatever to do with those two things. But this dark color, which chemical analysis shows to be due to organic matter, comes largely from the soil and vegetation in those basins; there is no doubt about that. Now, as I have said, I have not seen any evidence that that has any serious effect upon health. I have no doubt that, when the water had that cucumber taste, it had an effect upon health through the imagination, if in no other way. But I never supposed the soil had anything to do with it.

Q. We did not suppose the soil had anything to do with that; but we supposed it had something to do with the nauseous taste last fall, which has caused the chief outcry and clamor against the condition of the water.

A. Well, I was on here once or twice during the summer, and a

number of times after the first of September, and I did not see, and do not now see, that there is much difference between your water and the Croton, except that it has a somewhat deeper color.

Mr. GREENOUGH.—In other words, Mr. Davis, your position is, that, although it might be a good thing to take out that loam, it would cost so much the city would not get the worth of the expenditure?

A. Yes, that is about it; and I think you would not find much difference in the water after it was done, unless you take *all* the soil out. You would find some difference; but you would not have pure water,—what people are asking for.

Q. Why should we not have pure water, except the discoloration?

A. That is the point. It is the color, as I understand it, that people are objecting to.

Q. We find by analysis that the water is whiter after staying in the basins, although it contains more matter in solution.

A. That would be a new feature to me, and something I never knew before. We supposed the vegetable matter gave it the color, and I do not know how, when the color decreases, the organic matter taken up in the basins can increase.

Dr. BLAKE.—Are you so liable to have *algae* and water-plants growing upon the margins of a flowing river as upon the banks of a stagnant pool with low margins?

A. I want to separate *algae* from ordinary water-plants. Water-plants will grow upon the borders of a river or a pond of still water; but nobody knows whether soil is necessary or favorable to the growth of *algae* or not.

Q. The testimony we have had is that the three conditions necessary to the growth of *algae* are shallow flowage, heat, and organic vegetable matter. We have those conditions?

A. Yes, sir.

Q. And consequently a higher temperature of water?

A. There is much less trouble in flowing water than in basins. But to answer your question in a general way: This growth of *algae* occurs in lakes in the upper part of Maine, where people seldom go except for fishing purposes; it occurs, I am told, in Lake Winnipiseogee. Where there is shallow flowage the general temperature must be higher than where there is none. But those lakes where the *algae* grow often have clear, pebbly bottoms.

Q. And with shallow margins? It occurs upon the margins and is then diffused by the action of the wind. Why do you not have *algae* growing out in Lake Wenham, where there is a great depth of water?

A. I do not know whether they have it there or not.

Q. I do not think they do to the same extent. In the preparation of new basins would you take any greater precautions as to cleaning of the bottoms by removing the soil and deepening the margins?

A. I think I should, with the present light, knowing that the water surface was to be drawn down several feet each year in hot weather.

Mr. SHEPARD. — To what extent?

A. I could not tell you unless I went out on the land and looked it over. In a general way I should say I would clear away soil and increase the depth where there is not seven feet of depth at high water.

Q. Would you advise that that be done now?

A. I do not think you can do it to any extent, except in Basin No. 1.

Q. Because we cannot afford to lose the supply?

A. Yes, sir.

Q. Is that the only reason?

A. That is the chief reason. You cannot put the basins out of use long enough to do it.

Mr. GREENOUGH. — If one basin was down in the summer and comparatively empty, you might take out some soil then?

A. Yes, sir; you could do it in a very small way. I want to impress upon you that it is an enormous job, if you undertake to take out the soil generally, and it involves an enormous amount of work. You cannot hire carts enough to do it, but you have got to lay railroad tracks, and you have got to dispose of your soil. I suppose that the Water Board have, or if not they should have, a body of men through the summer taking out this deposit when the water is low in the basins.

Mr. SHEPARD. — Have the Water Board proceeded in that matter, Mr. Wightman?

Mr. WIGHTMAN. — Yes, sir; they have done considerable of it. When this Commission first went up there to look at those basins, you saw some men at Basin 2?

Mr. SHEPARD. — I do not recollect.

Mr. WIGHTMAN. — They have been at it all summer. They have done a great deal at it this summer. There are two or three coves that were cut off by the road at Ashland, and all of that has been dug out. They kept on digging until the water drove them out.

Mr. SHEPARD. — In preparing this new basin, where you have removed considerable of this soil, have you found any difficulty in disposing of it?

Mr. WIGHTMAN. — I have done just what Mr. Davis said would have to be done. I have spent fourteen thousand dollars in laying a branch track in there to take the loam out of the basins. I have taken it from the sides of the basins convenient to the track. We shall take it out and bring it to Boston, or let it remain there until it is wanted somewhere in the city.

Mr. SHEPARD. — Have you estimated the expense of taking out the loam in Basin 4?

Mr. WIGHTMAN. — I could not tell you what it would cost to take it out of the basin and simply deposit it just outside of the limits of the basin; but to take it out of the basin and get it to Boston, it costs approximately about \$1.50 a cubic yard. It would cost the Park Department about \$1.00 and the Water Board about 50 cents a cubic yard.

Mr. GREENOUGH. — How much are you calculating to take out?

Mr. WIGHTMAN. — About 200,000 yards. It will depend upon how much they want for Commonwealth avenue, and whether they will go on with the Muddy-river Improvement. They want about 100,000 yards for the Back Bay park, and 50,000 yards on Commonwealth avenue, and if the Muddy-river Improvement goes on they wil want about as much more.

Mr. SHEPARD. — Suppose this was not needed by the Park Commissioners at all, and you had no way of disposing of it with advantage to the city, would you remove the loam simply as a question affecting the water in the basin?

A. I am simply taking it out a little deeper than Mr. Davis mentions, down to about twelve feet from the high-water line. That is all I should do, and that is all I propose to do.

Mr. SHEPARD. — You think that advisable to-day, looking at the water supply only?

A. Yes, sir, it is a question of judgment solely, as regards that depth. This is a very narrow and deep basin, and of course the fluctuations will be greater. I am not taking it out of the shallow basins more than seven feet.

Dr. BLAKE. — Do you know, Mr. Davis, whether any other cities with a water supply like ours have periodical cleansing of their storage-basins?

Mr. DAVIS. — I never knew it to be done.

Dr. BLAKE. — I think it is done by the city of New York. Did you not so understand, Mr. Greenough?

Mr. GREENOUGH. — I understood Mr. Dresser to say the reservoirs in the city were cleaned; but not the reservoirs upon the Croton.

Mr. DAVIS. — They have never, I believe, cleaned out the new reservoir in the park.

Mr. GREENOUGH. — They cleaned out the Forty-second-street reservoir.

Mr. DAVIS. — It has been the custom to clean out the Brookline reservoir here, I think.

Mr. BRADLEE. — I think it had not been cleaned out for thirty years when it was cleaned the last time.

Mr. DAVIS. — The East Boston reservoir was cleaned out.

Mr. WIGHTMAN. — And it might be said right here that not enough deposit was obtained to pay for cleaning it out. The deposit was very slight.

Mr. DAVIS. — New Bedford built their works in 1867-8, if I remember rightly. They flowed a swampy territory by a dam not more than seven or eight feet high. When the water first went into the city the color was very deep. The people objected to it because they were used to clear water from wells. But there has been no soil taken out that I am aware of, and I never heard that it produced any ill effect upon health. I have opened this book to a point where it gives the testimony taken by commissioners in London, appointed to get at the question of impurity of water. The Commission, in their report, say (reading from pages 30-31, Doc. 29, 1873) : —

The organic compounds dissolved in water appear to be of very instable constitution and to be very easily decomposed, the great agent in this decomposition being oxygen, and the process being considerably hastened by the motion of the water. Now, as such waters (river waters) always contain naturally much air dissolved in them, the decomposing agent is ready at hand to exert its influence the moment the matter is received into the water, in addition to which motion causes a further action by exposure to the atmosphere.

The effect of the action of oxygen on these matters, when complete, is to break them up, to destroy all their peculiar organic constitution, and to rearrange their elements into permanent inorganic forms, innocuous, and free from any deleterious quality.

It does not follow that all organic matter in water is prejudicial. Almost all our drinks, other than water, owe their distinctive qualities to the varieties of their organic contents.

Dr. Lyon Playfair, Professor of Chemistry in the University of Edinburgh, in his testimony before the commissioners, states:—

The effect of organic matter in the water depends very much upon the character of that organic matter. If it be a mere vegetable matter, such as comes from a peaty district, even if the water is originally of a pale sherry color, on being exposed to the air in reservoirs, or in canals leading from one reservoir to another, the vegetable matter gets acted upon by the air, and becomes insoluble, and is chiefly deposited; and what remains has no influence upon health.

Mr. GREENOUGH. — Are you familiar with the water supplies of any large European cities, Mr. Davis?

A. Well, I know something about them. For instance, I saw the Berlin supply where the water is filtered. The water is pumped from the river Spree, filtered, and then pumped into the city. The Paris supply comes from various sources. About two-thirds of it is used for street purposes, and only one-third is carried into the buildings for domestic purposes. They keep the two supplies distinct, and have two distinct sets of pipes running throughout the city. I will say here in reference to this question, that in this country we have got to very much restrict the use of water, which is what the superintendents of water works have been aiming at for the last fifteen or twenty years, without being able to obtain sufficient authority; or else we have got to bring in a special supply for drinking and culinary use. With the drainage area required to supply Boston, it is impossible to get a supply free from pollution, and it is impracticable in this climate to purify water by filtration in such large quantities as are needed for general use. I suppose that Lake Cochituate could be defended against pollution, and if its water were kept separate you could deliver sufficient from it for purely domestic purposes. It is possible that you could improve the Sudbury-river water by blowing air through it. I understand the city proposes to build a conduit across Farm pond, and it might be so arranged that air could be blown through it, so as to let the oxygen attack in all parts. I have no doubt it would very much improve the quality of the water. I did not know but you might want to ask me something in regard to special cases of sewage pollution, as at Pegan brook and South Framingham. Within a few days my attention has been called to what is known as the Farquhar filter. There is one on exhibition in New York, and I went down last Saturday to see it in operation, so as to be able to say something about it. I have

one of the reports of the inventor, which will give the information in detail.

Q. What is its peculiarity?

A. It is simply keeping a fresh surface at all times, and filtering under pressure. Filters usually choke up so quickly that you get but a small result after a few hours' filtration.

Mr. SHEPARD. — Is this filter to be used on faucets?

A. No, sir; I presume it was gotten up originally for manufacturing purposes, to be used in breweries, sugar refineries, etc.; but they propose to use it for filtering the water supplies of towns. Here is the report of an experiment they made in filtering the water supplied to Paris, mixed with the mud and sewage of the city, till it had 500 milligrammes of suspended matter in each litre of water.

Mr. GREENOUGH. — You do not suppose any such filter could be used in our water supply, do you?

A. I bring this to your attention as a possible means of filtering the portion of the supply which is subject to sewage pollution, and not to filter all that comes into the city.

Q. Do you think that would be possible?

A. Oh, yes.

Mr. SHEPARD. — At what expense?

A. I cannot answer that.

Q. Is it a very large expense?

A. Here is a cut of the machine. The inventor says that a machine ten feet in diameter would filter a million United States gallons a day of such water as is ordinarily supplied to cities. Of course it depends upon the quality of the water as to how much would go through it. The water would have to be pumped up; the filtering is under pressure. I do not bring that before you to recommend it, for I know nothing about it. My attention was called to it only a short time ago, and it was only because I knew that you wanted me to come before you that I looked at it at all. I saw a little model of it at work. Ink would look almost clear alongside of the stuff they put into it, and it came out perfectly limpid. They said it was such water as is found at the bottoms of coal mines,—water mixed with bituminous matter and clay.

Mr. GREENOUGH. — This would not take out the dangerous matter held in solution?

A. It takes out organic matter, according to that French report. It did not take out the chlorine. I merely draw the machine to the attention of the Commission; and if they want to investigate the matter further they will have to do so, for I have not investigated it enough to recommend it.

Dr. BLAKE. — Have you any suggestions to make as to methods for purifying our water?

A. Nothing that I know of, further than what I have said. I think the question of blowing air through it is worth study. I should not dare to recommend it with any knowledge I have on the subject now, but I think it would be worth while to experiment pretty thoroughly about it.

Q. You would recommend a larger number of supply and storage

basins, so as to allow the water to remain in them, and so as to clean out one or more if necessary?

A. Yes; that is a part of the original plan, and it is very desirable. With the present consumption there should be much greater storage capacity at the source of supply.

Mr. GREENOUGH.—Do you consider that more desirable than a reduction of the consumption?

A. I consider that the most crying want of most of our water supplies is the reduction of the consumption of water, because there are many attendant evils outside of this question that you are considering now. The 1873 report on the water supply is based upon the city using 60 gallons a day *per capita*, and you are using 90 or more. At that rate you will want another source of supply before many years.

Q. Any supply obtained as ours is, during the hot weather is liable to be affected by the sun?

A. Yes, sir; all surface-waters are.

Q. So all you can do is to cut off that portion which happens to be pure?

A. Yes, sir.

Q. And you can cut off that by increasing the supply or decreasing the consumption?

A. Yes, sir.

Q. And if you decrease your consumption you are much more able to handle your water, and keep it pure?

A. Yes, sir.

Mr. SHEPARD.—In speaking of different supplies, one for domestic purposes and the other for streets, I suppose that would mean for cleaning the streets, the fire department, and all that sort of thing; and you would have but one supply to go into the houses?

A. I should have two supplies for the houses.

Q. Then how are you going to compel the people to separate them? How are you going to prevent them from using the pure water for washing, etc.?

A. I would not allow them to connect the pure water with the water-closets and bath-tubs, where a large part of the waste occurs. The pure supply would be connected with a faucet, where it could be wasted to a certain extent; but I would not allow more than one faucet to a floor. I do not think that in Paris they carry both supplies into the houses; but they use enormous quantities of water for fountains and in cleaning the streets. Early in the morning they will let the water run into the gutters and wash the street cleanings into the sewers. The total supply, including this two-thirds which is used for street purposes, is very much less per inhabitant than the Boston supply. That which is used for street purposes comes from the canal de l'Ourcq and from the Seine. The supply for the houses comes from three or four different sources. The one I saw comes, if I remember correctly, about 90 miles, and is collected from some little springs. It is quite hard water, and our people would object to it on that account; but it is perfectly pure so far as concerns organic matter.

Q. Would it be practicable to supply the Cochituate water for domestic purposes and the Sudbury for other uses?

A. Yes, sir; it is practicable; but you would have to lay a new distribution system.

Q. It would be very expensive?

A. It would cost something; but it would not be anything like as large a system as you now have,—not so large a size of pipes. There is no large source of supply that I know of that it is practicable for Boston to take,—and almost all our cities are similarly situated,—with which you will not have difficulties similar to those that you are having now. To attempt to purify the water in the quantity that you are using would be excessively costly.

Q. Is not the question of giving a special supply for faucet use one that we have got to meet?

A. A great many of our cities would be perfectly content with water that other people would find a great deal of fault with.

Q. Take Boston, for instance.

A. It depends upon what the people are going to demand. If they demand water clear to the eye and entirely free from pollution, you will have to meet it in that way. If they are content with water that is not shown to be actually dangerous to health, the question then is a different one.

Q. I suppose it is very difficult to show that it is positively dangerous to health.

A. I do not know that it would be so. I should not think it would be very difficult to show, provided it really is.

Q. The experts who have appeared before this Commission have testified that, in their opinion, it is so; but they cannot bring up special cases and say that that disease was caused by the water.

A. There are volumes of evidence to show that disease is produced by impure water; but it is usually well-water, or water from small supplies. Now, if it is easy to prove in those cases, I should think that it would be much easier to prove that a disease came from a large supply, because it would be more wide-spread. There is considerable evidence that cholera was produced in London from one supply there; but a more thorough analysis of that evidence in later years has led to a good deal of doubt about that.

Mr. SHEPARD. — If I remember rightly they took some testimony in London a short time ago concerning the sewage pollution of one of their water supplies, and it was very concurrent that all sewage should be kept out of a water supply because it was injurious to health; and yet none of the experts could point to a single case.

Dr. BLAKE. — I suppose you have reference to the Snow-street pump, Mr. Davis?

A. I do not refer to any particular case. But in this country, and in England and Germany, there have been plenty of cases where disease was directly traced to impure water; but I do not remember where it has been traced to a large public supply. If an epidemic was produced, it seems to me it could be shown whether it was caused by the water supply or not. How much effect water which, from its color or other cause, is not pleasant to

the senses has upon people who are sick, I do not know anything about; but most such people could easily be provided with water brought in here in barrels, if necessary.

Q. Upon general grounds you would exclude large contaminating sources?

A. Oh, yes. I am only referring to what is practicable. A water supply cannot be too pure.

Mr. GREENOUGH.—Do you know any large cities where they take any more care than we do in the preparation of their basins? How is it with Baltimore?

A. Baltimore did not, as I understand, have to take any care. Their basin was in the bed of the river, as you might say, and it is rocky, so I am told,—I have never been there. A good many years ago Albany dammed up a small stream, and they had a great deal of trouble with their water; but I do not think any soil was removed. Troy got water in about the same way. Worcester got water in that way. New Bedford I have mentioned. Lynn gets its water in that way.

Q. Have they not had trouble at Springfield?

A. Yes, sir. Springfield gets its water in that way.

Dr. BLAKE.—And all the towns around Boston have the same system, and all have the same source of complaint?

A. Most of them. Salem, however, gets its supply from Lake Wenham.

Mr. GREENOUGH.—In other words, there have been experiments for the last twenty years in this country, and they have pretty much all had the same trouble?

A. Yes, sir.

Mr. GREENOUGH.—The question is, what is to be done about it?

Dr. BLAKE.—The what to do about it is, to try some other method. We have had pollutions enough of that kind.

Mr. DAVIS.—I do not know any other large source of a different character that Boston can obtain, except the Merrimack river, and there would be the objection of cost there.

Mr. GREENOUGH.—We would require storage basins in that case?

A. No, sir. It would require settling-basins and filters, and two sets of pumping apparatus. The first cost was estimated, in 1872, at thirteen million dollars; and then there is the yearly cost of settling, filtering, and pumping.

Q. How would it be about the Charles?

A. It is exactly the same as the Sudbury.

Q. You would have to store your supply from the Charles?

A. Oh, yes. There is nothing available for Boston, that I know of, except this kind of a supply.

Q. Unless you went to the Merrimack. You would have the same trouble with the Sudbury and the Shawsheen?

A. Yes, sir; and with the Merrimack. Those people who are troubled about sewage pollution would have trouble on account of the large cities above the point of taking the supply. A large number of English scientists testified that if one of those germ

that produce disease got into water, there is no reasonable distance the water might travel that would eliminate that germ from it. As a matter of fact, however, we find people using water which has been polluted some distance above the point from which it is taken, and they have never been able to trace disease to the water. In saying this I do not wish to be understood as favoring the use of water that has been polluted by sewage.

Dr. BLAKE. — The germ flourishes in a certain kind of soil, and when it finds a person in a proper condition to be acted upon, it will soon cause an ulceration in the stomach.

A. Yes, sir; I do not deny the statement. But if the argument is carried in other directions as far as it often is with the water supply, — I am speaking particularly about what has been said in England, — you would be afraid to breathe the air in our streets.

Mr. SHEPARD. — Mr. Wightman, have the Water Board had an examination made by Prof. Wood of the water as it comes into our pipes in the city?

Mr. WIGHTMAN. — No; I do not think they have.

Mr. GREENOUGH. — I do not see that you give us very much advice, Mr. Davis, as to how we can better our supply?

A. No, sir. I do not see but that you have a question before you that is exceedingly difficult to deal with. As I have said, the thing I used to hear talked about as much as anything else was the Pegan-brook pollution. I think that can be handled. I think any of those sewage questions can be handled. If the Commission are going into that question I would suggest that they examine this filter. That sewage can be diverted. We made surveys for the diversion of the sewage from Sudbury river while we were building the works. We proposed to take the sewage down below Saxonville, and use it for agricultural purposes, — that is, the drainage from Natick, Ashland, and Marlboro'.

Mr. SHEPARD. — Is it going to be expensive to divert the sewage and take care of it?

A. If I remember the figures, about three-quarters of a million dollars would have built a scheme of works which would have taken the Marlboro' and Ashland sewage, and the Natick and Framingham sewage. Those towns should be made to pay a large portion of that expense.

Q. What would be the running expense? You say you were going to use it for agricultural purposes?

A. There would be no pumping. The farm would be run at a loss; that has been the experience abroad. But it would not be a heavy expense.

Q. The city would have to run that farm; that is, you mean to spread the sewage abroad upon some farm the city would carry on. You do not mean that the city would dispose of it to the town farmers who might want it?

A. No, sir; the city would own the farm. The estimate included the cost of the farm.

Q. Why was nothing ever done?

A. With the exception of Pegan brook there was nothing pressing. I think, probably, the city would have had some report in

reference to it before this time, if it had not been that the Legislature appointed a commission to consider the subject of metropolitan drainage.

Mr. WIGHTMAN. — All that information was before the commission on metropolitan drainage. We gave them all this information and the surveys.

Mr. SHEPARD. — Suppose the city should go ahead and build such works, in case the State ever does establish a metropolitan system of drainage, they would take the city's works at a fair valuation, as they would our intercepting sewer?

Mr. DAVIS. — I would like to answer your question a little further, Mr. Greenough, in relation to vegetable organic impurity, and the question of increased capacity or decrease in consumption; as I have said before, I am not aware that such impurity in moderate quantities is noxious to health. The testimony before the royal commission on water supply, taken in 1868, was practically unanimous on this point. It is only this class of impurities that will be affected by removing the soil, and to produce much benefit *all* the soil — from the valley bottom, as well as from the slopes — must be removed. This is now impracticable in Basins 2 and 3, even if it ever was judicious. The money it would cost had better, in my opinion, be used in, 1st, preventing waste; or, 2d, in increasing the number of storage-basins, that the water in the basins may be kept at a more uniform level, and that in case of necessity an offensive basin may be thrown out of use till the trouble is removed. Longer storage, and exposure to the air and sunlight, will certainly reduce the color and bitter taste. Sewage pollution is another matter, and must be treated at the point where it occurs.

Mr. GREENOUGH. — You do not think we can materially improve the basins we have except at a very large expense?

A. No, sir.

Mr. SHEPARD. — And the further objection is that we cannot do it, because we need the water.

A. You cannot do it in Basins 2 and 3 unless you provide other storage; and I presume Basin 1 is little used for the supply of the city. It was not thought its level would be much drawn down. It is a shallow basin, and the dam was made more to divert the water into the conduit than for storage purposes. The two upper basins are connected directly with the conduit, so that you can obtain the water from them without mixing it in Basin 1. If Basin 1 is to be used as a storage-basin to be drawn down to any large extent, there ought to be a great amount of work upon it, because there is a large amount of soil and shallow flowage. But, so far as Basins 2 and 3 are concerned, I do not see how it is practicable to do much; and what is necessary to be done I presume the Water Board are doing, and have been doing.

Mr. WIGHTMAN. — We used Basin 1 principally to keep up that daily supply of a million and a half gallons to the river below.

Mr. GREENOUGH. — You have no personal knowledge of the New York water works, Mr. Davis?

A. I have been over them.

Q. They have taken no special care in the preparation of their basins?

A. No, sir. But their soil is not so rich as yours, except in the valley bottoms. There is not so much soil upon the slopes as upon yours.

Dr. BLAKE.—The character of their grounds gives them deeper storage-basins?

A. Yes, sir; very much.

Q. And they have been in use twenty years, and have reached that condition of natural ponds by this time?

A. Well, Croton lake has been in use forty years or more. Other basins have been built since.

Q. And the water flows twenty miles exposed to the open air before it enters the city?

A. No, sir; it flows direct from Croton lake in a covered conduit, and is carried into the reservoir just as it is here. But there are basins and ponds higher up the country, and the water from them flows a considerable distance before it reaches the lake.

Adjourned to Monday, January 15, at 4 P.M.

FIFTEENTH HEARING.

MONDAY, January 15, 1883.

The Commission met at 4 P.M.

TESTIMONY OF DR. CHARLES SEDGWICK MINOT.

Dr. BLAKE.—Dr. Minot, I took the liberty of suggesting that you be invited to tell us something about the manner in which the city of Leipsic is supplied with water. I know that you have been there recently, and we are engaged in investigating the water supply of the city of Boston, and wish to obtain all possible light upon the subject.

Dr. MINOT.—I shall be very glad to give the committee any information I possess. I will say a word of explanation first. I knew, upon going abroad, that our water supply required investigation, and that it was desirable that as many as possible should know the necessities of a good water supply. Being in Leipsic, among scientific persons, I took advantage of the opportunity of there meeting Professor Hoffman, who is a professional hygienist, and a member of the city government. From him directly I got information, and we spent a couple of days together, which were mainly devoted to the water supply of Leipsic. He had promised to send me the documents which had been published, and which would place at my command all the exact details of the information as to quantity used, the condition, and all necessary data. These papers I have not yet received; but I think I can give you accurate information, as long as you do not insist upon the exact figures.

The water supply of Leipsic was first built a number of years ago by persons without any experience or knowledge of the subject. The water was exceedingly bad, and very insufficient in

quantity. They made an investigation, which was put in charge of Hoffman. He found the principal contamination was due to a supply of iron in the form of proto-oxides, which came directly from the soil, and that the territory from which the city of Leipsic was supplied was more or less contaminated with this oxide of iron. Thus the water was often rendered unfit for drinking. This difficulty was remedied by flooding water over the pipes at the point of principal contamination, in order to produce a flow away from the pipes, to carry thus the iron away, and prevent the iron salts from entering the supply-pipes laid in the soil. It was known that the town was growing rapidly, and an increased supply had to be sought. The problem was a difficult one. Leipsic is situated on a low plain. Its total elevation above the sea is 150 metres, — perhaps in the neighborhood of 500 feet, — and there are no mountains of any size, or elevated land, in its neighborhood. The water, then, would have to be drawn from some low source, and power used to give it the necessary pressure. It therefore seemed to them that they must draw the water from the soil. An investigation was proceeded with, which led them to the conviction that not only was it best in their case to take water from the soil, but that, whenever it was possible, the water should always be taken directly from the soil, and not from any standing body of water, or from any flowing stream. This investigation was carried on with great minuteness and thoroughness under the direction of Professor Hoffman, and his statements rest upon an ascertained body of facts.

The advantages of the soil-water when taken at sufficient depth, and from a proper point, are that it has a constant composition, that it is not exposed to any temporary alterations in its composition or to any temporary pollution. It has also another great advantage, that of a low temperature, which is a very considerable one, being, I believe, considered advantageous to the water in use, and, from a hygienic point of view, advantageous because a low temperature is unfavorable to the development of lower organisms. That the composition of the water is so constant depends upon the fact of the filtering down, the matters in solution being retained partly by the soil, for no water can pass through the soil without leaving some of its soluble contents in the soil; and if there is in excess of any substance in the earth the water dissolves a portion of that, so that upon arriving at a certain depth the water has always approximately the same composition. This point settled, that they must take their water from the soil, they proceeded to explore the neighborhood of Leipsic by a system of borings which were conducted by the engineer. They made borings leading directly down into the earth, and ascertained the depth of the water at different points. They then drew up a map of these levels, — making, of course, explorations in those directions which seemed most favorable for a water supply, — and from the comparison of those different levels the flow of the water was determined, because, of course, the water flowed towards its lowest level. They did not have to go to a very great depth to find water; in low valleys I think not often beyond a depth of fifteen

or twenty feet. They found that the level of the water in the soil represented a subterranean lake, and was independent of the configuration of the surface, by which, therefore, they could not be guided very much. By this investigation they found the level of the water, and, also, something of the character of the soil. They found that a large deposit of glacial gravel had been left spread over this alluvial plain, over which formerly had run a large river bed,—that of the Mulde in that neighborhood. They succeeded in tracing the bed, and finding that it was actually a stream of water flowing through the soil; and there, at a certain point, where the greatest flow took place, they tapped the supply, put in their boring, and were able to draw from that single boring by pumping a quantity of pure water which was nearly sufficient for the entire city of Leipsic,—Leipsic having a population of 150,000,—and, if I remember correctly, though that point I am not positive about, the daily use is about forty gallons. These works were not completed at the time I was in Leipsic; they were being still carried on. The system is, after having determined where the pipes are to be laid, to make trenches and borings, and to lay porous pipes in them, and connect with a main to conduct the water towards the city. These pipes are laid below the level of the water. The supply which is obtained is very large, because they find that this soil is entirely saturated with water at a certain depth. There is there, as probably in every country with anything like a similar constitution of surface, a supply of water at a certain depth below the surface, which supply is of very great extent, because it fills up, as I said before, the whole space between the particles of the soil; and it can be shown very easily that the amount of empty space in a deposit of gravel is about one-third of the total space occupied, so that one-third is water and two-thirds solid matter. This, then, virtually gives them an unlimited supply, which they are perfectly certain of as long as the country remains in its present condition, which is one of superficial cultivation, with only a small number of habitations about it.

The emphasis which Hoffman laid upon the advantages of soil-water made a very deep impression upon me, and led me to think that in proposing to enlarge any further our system, or to build a new one, in this country, due consideration should be given to the possibility of having the supply drawn entirely from the soil, because of its greater purity and constancy of composition, and its freedom from accidental pollution; and upon inquiry I find that in London the water supply which comes from deep springs, and which is, therefore, soil-water like this, and which is supplied by the Kent Company, is purest. Though I do not speak with the greatest confidence of that fact, I think that is correct; and in this country there have been similar experiments, which I believe have been very successful.

Dr. BLAKE.—In Brooklyn, N.Y?

Dr. MINOT.—In Brooklyn, N.Y. So that there seems to be a great deal to suggest the advantages of that method.

On the other hand, the disadvantages of any superficial supply of water were shown by the experience in Leipsic in first laying

pipes where they laid them, — in low, marshy land not very far from villages, and not very far from a small stream which runs into Leipsic, which is not very pure. These pipes were not laid very deep, and the nature of the water was not determined beforehand. Its composition was exceedingly bad, and produced a great deal of sickness in Leipsic. Undoubtedly the expense saved to the city by the appointment of their scientific commission was very great. The city had proposed, up to that time, to extend the same source of supply further out, where examination showed, however, that the water was a great deal worse than where they started.

In regard to the other method of water supply there is something which has been suggested by the experience of Leipsic, which might prove to be of interest, perhaps. They also, took up the question of a supply to be drawn from rivers and ponds, although those in the neighborhood of Leipsic are small and unimportant. They found, as other chemists have found, that the supply from ponds and rivers is always uncertain, is always less satisfactory than that from the soil, and is necessarily so, because the washings from the surface are gathered into it whenever there is a heavy rain. These, I suppose, are well-known facts to you. They led me to make some further inquiry as to the manner in which they got rid of those terrible impurities to which they had been subjected in their original supply. Hoffman gave me, as the result of their experience, the rule that the vegetation should not be disturbed more than necessary, but that abundant and ample growth of vegetation was necessary for the purification of the water, and that the taking out of that vegetation was largely a mistake ; that it would be better in many cases to leave the bottom entirely undisturbed, and let the vegetation exert its uncontrolled purifying influence ; and he instanced a great many cases in which that had been done, and also other cases in which it had not been done, which he followed up by comparisons, and stated to me the figures of his analyses, which I do not recollect. He then went on to say that they had suffered particularly when they had attempted to clean out their basins, which are small, or not very large. If they drained them off, and cleaned them out, they found it was the worst thing they could do, — the worst process of purifying which they had tried, — because the draining off necessarily killed the organisms of the plants and vegetables in the water ; that no pond could be completely cleaned out, except with great difficulty and much labor ; when you put the water back you have artificially killed the organisms, especially the animal, which immediately proceed to decay, and which in a half-decayed condition were dangerous ; the difference between the ordinary process of decay and the artificial process being that, in the ordinary process, the organic decay takes place with considerable rapidity, and that if you accomplish the dissolution of any organic matter it is perfectly dangerless. That is to say, if you swallow food it decomposes completely, the decomposition takes place in a few hours, and there is no danger from it ; if you allow the same food to decompose slowly, it is dangerous. With the natural supply of decomposing agents in water, which is left undisturbed with an abundance of clean water, there really occurs a rapid

decomposition ; when you drain off the water and then clean up as well as you can, and put the water back, you have an accumulation of matter which is so great that decomposition is necessarily slow and dangerous.

I believe there is only one other point which struck me as being likely to be of interest, especially to you, and that is that, according to the source of the water, the manner of storing it should be varied ; that if it is taken from an open supply, a pond or river, the storage-basins should be large in order to allow rapid settling and purification of the water. If you allow it to be spread over considerable surface, you allow vegetable action to take place in it. If, on the other hand, you draw your water from the soil, it is best to store it in a small reservoir, where the water is constantly running, because you must preserve it in its pure condition, and when so stored it is much less exposed to contamination.

Dr. BLAKE.— Doctor, you are familiar with Boston's system of water supply,— drawing from the river and storing in basins?

A. Yes, sir.

Q. Do you know the manner in which the basins were prepared for the storage of the water?

A. I am not familiar with all the details of it. I believe that in part marsh and low lands were converted into basins.

Q. Without any preparation?

A. Without any preparation.

Q. Do you consider that a desirable method of procedure?

A. I should think it was a very unfortunate method, one which would certainly lead to contamination of the water.

Q. If you had been consulted in regard to the preparation of those basins, what conditions would you think absolutely necessary to preserve the purity of the water?

A. I should think, in the first place, the removal of all the alluvial soil, of all the superficial soil distributed upon the surface down to a gravel or sandy bottom, as the case might be ; and that any soil which had any formation of organic matter in it should be entirely removed.

Q. You would do that before admitting the water?

A. Before admitting the water.

Q. And you would also, I presume, obtain, if possible, a considerable depth in all parts of the basins, would you not?

A. Yes, sir.

Q. And that with a view to obtaining a low temperature of the water?

A. Yes, sir.

Q. Provided that these measures were not taken at the beginning, would you deem it advisable, if circumstances permitted, to draw off the water from one of these basins at a time, remove the alluvial soil and decayed loam, and then allow the water to go back again?

A. I should think that that would be a hazardous experiment, unless it was treated like the making of a basin originally.

Q. If we were able to completely empty one of these basins which had not been properly prepared in the beginning, after

emptying the basin and removing all the soil and loam during cold weather, the water might then be returned with very little danger?

A. I think so, in that case. I think the essential condition would be to do it during the cold season, however, — after the cold weather had begun.

Q. If you were consulted by the city as to the best method of preparing storage-basins for the future you would insist, then, upon the removal of the loam and the soil, and the obtaining of a considerable depth for the basins, would you not?

A. I would insist, with our present system of supply, that these are indispensable conditions.

Mr. GREENOUGH. — Dr. Minot, do you take the ground that the existence of the soil on the bottom of these basins would prove to be deleterious to the public health?

A. Yes, sir.

Q. What would you expect to be the effect upon the public health?

A. I think the effect of it is that it is a source of organic decomposition. It is a great storage of partly decomposed organic matter which forms that soil; and the moment you put water upon it decomposition sets forward again, and the water is necessarily contaminated with the gases developed by decomposition and with the soluble organic matter which is also formed. I think these are inevitable results.

Q. Well, I believe the proportion of one part in ten thousand is supposed to be healthy.

A. I think what proportion is healthy may be determined by chemical analysis. It may interest you to know that the subject will shortly be treated fully in a report by Prof. Leeds, of Hoboken, N.J., who has taken up that question. I think that it will undoubtedly be a thorough discussion of the subject. I think they are all agreed that it is not safe to put any absolute limit as to what proportion is certainly healthy or unhealthy.

Q. When do you expect that report will be published?

A. Probably in a few days.

Dr. BLAKE. — Is it generally understood among chemists that, when you obtain by chemical analysis more than a certain per cent. of solid matters in water, such water is liable to become dangerous to health?

A. I think so.

Q. I suppose the nature of the solid matter would have a good deal to do with the healthiness of the water?

A. Certainly.

Q. I take it that any water holding a large percentage of organic matter, under certain circumstances of temperature and conditions, will become an element dangerous to the public health?

A. Certainly. There is one other point, which does not come directly from what I saw in Leipsic, which, if gentlemen will permit me, I might mention, and that is, the independence of the healthfulness of water from its taste. I think it is considered by a good many persons — and I am one of them — that the attention which has been directed to the taste of Boston water is unfor-

tunate, for this reason : that we may have water which is perfectly tasteless and perfectly pure in its appearance, and which is yet in an extremely dangerous condition. Taste is not an index to the hygienic condition of the water. Not only is it true that we may have water which tastes perfectly well, and may yet be unhealthy, but the opposite is true, — we may have water which tastes badly, but which is perfectly safe to drink.

Q. I suppose that water contaminated by sewage might be tasteless and very agreeable to look at, quite clear and free from anything disagreeable in color as well as taste, and yet be extremely dangerous to health ?

A. Certainly.

MR. GREENOUGH. — I want to ask you a few more questions about this Leipsic system. As I understand, they pump the water from a large pipe to which a number of feeders have been brought, which drain the water from what is called the water level in the ground ?

A. Yes, sir.

Q. To what extent do they carry those feeders ?

A. They do not carry them to any great distance. They have a long tube which runs in the direction of the stream, and they have a series of cross tubes, — smaller pipes running laterally, — and those pipes will not be more than a few hundred feet (I think) long on each side. At present the pipes are not very long, because from a pretty small area they can gather an enormous supply under exceedingly favorable circumstances.

Q. They pump only for the daily use ?

A. They have a reservoir which holds enough for daily use and for fires.

Q. Comparatively small ?

A. A comparatively small reservoir.

Q. They pump forty gallons per inhabitant per day ?

A. Yes, sir.

Q. Six millions of gallons per day ?

A. Yes, sir, if my recollection be correct.

Q. Well, that condition of things can only exist under exceptionally favorable circumstances, I should imagine ?

A. From what I saw there, I should think not. I should think that in a majority of cases it would be possible to draw upon the soil for water.

Q. Take this case, for example : where there are no underlying strata to any extent, if you bore for water in the vicinity of Boston you might get the drainage of some small area, but you are not liable to tap any large flowing stream, as in a country where the underground water-courses have not been interfered with.

A. You have here, in the vicinity of Boston, districts which are not very much inhabited on the surface, and there is no *a priori* reason of which I am aware why pipes might not be laid along the sides of a stream, and the water which flows down through the soil into that be drained off before reaching the river. It would practically be the same thing, only in one case the river which you do not tap goes on the surface, and in the other case it goes under the ground.

Mr. BRADLEE. — In this place you speak of are the pipes near a stream or river?

A. Near no superficial river. It is merely the flow of the water in the ground.

Mr. GREENOUGH. — Where does it flow to?

A. They have not followed the stream to its definite outflow. It probably flows off and joins the Elbe.

Q. Do they suppose they are taking water which has run under ground for a great distance, or that they are simply tapping soil-water which has settled through the ground?

A. They think it is filtered water from the general surface.

Q. They do not expect to get a quantity of water which has drained down from the surface?

A. No. They get water which has flowed together from a very large superficial area, the peculiar feature being that there was this old river-bed, in which the water actually flowed, and now that river-bed has been filled up with gravel, which has been carried into it, and the gravel at the same time has been spread out on either side and makes the top of the land or earth upon which the houses are built; and now, when the water soaks down through the gravel and reaches the old superficial soil, it enters again the old river-bed, and, as it finds there in the loose gravel its easiest passage, it still passes along over what was formerly the river-bed and flows through the spaces in the gravel.

Q. Where they are able to find large superficial deposits of gravel, you would expect to find considerable water down below?

A. Yes, sir.

Q. In a great many places you could not do that without corresponding damage. It takes the water out from a very large neighborhood, and reduces its height in the wells sometimes.

A. That certainly is the case; but then the laying of this system of pipes at any place where there is water is a comparatively inexpensive process, for the water is not very deep below the surface. And the water works need not be carried on all at one point.

Mr. SHEPARD. — What is the quality of this water that they get at Leipsic?

A. It is very pure water, indeed. It contains a minimum quantity of organic matter, a small proportion of earthy salts to give a little sparkle to the water, and, I think, a somewhat large amount of carbonic-acid gas.

Q. Did they start with this plan by design, or was it suggested by accident?

A. They started upon it by design.

Mr. GREENOUGH. — Did they consider the subject of filtration, or have you given the matter attention?

A. I think in the London companies the experience with filtration has been unfavorable. They are doing it in most of the companies; but it involves very great expense, and is exposed to frequent accidents. The Kent company, which I believe draws its water from a deep source, escapes with much less trouble than the others.

Dr. BLAKE. — How much water does the Kent company obtain in that way, do you remember?

A. That I cannot tell.

Q. From your knowledge of the geological formation of Boston and vicinity, do you think any system of that sort would justify the expense and trouble of testing it?

A. I should think it was sufficiently possible to make it worthy of serious consideration, because there are very large areas of gravel deposit in the neighborhood of Boston; and it does not follow that, because the borings, which have been made on marsh lands and on land entirely surrounded by salt-water, where they were not able to properly test the soil or surface-water, were not successful, borings elsewhere would not be so. I do not think that would be sufficient guidance for forming a definite opinion in the matter.

Q. Well, from your knowledge of Boston and its surroundings and suburbs,—the neighborhood of Boston in a radius of a dozen miles,—does any place occur to you as favorable to a trial similar to that at Leipsic?

A. I should think that out in the direction towards the northwest, or towards the west, there might be localities where it would be desirable to try. But that is a question which I am not prepared to answer as an expert at all.

Q. Out towards Framingham?

A. Yes; in that direction, where we now get part of our supply for the city. I think that is a question that might be answered by local geologists. There is a gentleman at the Natural History rooms, Mr. Crosby, who is familiar with the geological aspects of that territory, and has examined it with considerable thoroughness.

Q. Do you think there is reasonable probability of our obtaining a tolerable supply of pure water in that way, sufficient to justify the experiment?

A. I should not be willing to take the responsibility of giving determining advice upon that point; but, as far as my knowledge of the matter goes, I should think it was very probable that it would repay the outlay.

Q. Under no circumstances would you allow sewage contamination to enter the city's water supply?

A. No. I think that is inexcusable. That cannot be defended or excused in any way.

Q. You are quite positive in your belief that sewage does not become innocuous by dilution, or by exposure to the atmosphere?

A. I think that sewage may certainly be rendered innocuous by dilution, oxidation, and precipitation. But the introduction of sewage is rendered objectionable by the peculiarity of our climate, which subjects us often to long periods of drouth, while the supply of sewage does not have any such diminution. It is a constant supply, and as the supply of fresh water diminishes the ratio of sewage increases to such an extent as to make it peculiarly liable to be dangerous.

Mr. GREENOUGH.—Do you consider that sewage can be purified by dilution?

A. I think it is doubtful whether dilution, unless it is carried to an extreme extent, is sufficient. But I think it is quite settled that oxidation and precipitation do suffice to render it perfectly

innocuous. In moving water that takes place with extreme rapidity, so that, I think, if we had an ordinarily constant supply of pure water we might, perhaps, accept a moderate admixture of sewage. But that is not the condition which exists.

Dr. BLAKE.—And the danger is so great that you are in favor of excluding it in toto?

A. I think so. I think, situated as we are, that would be the only justifiable course.

Q. Does water purify itself from decaying organic matter by aeration or oxidation and constant motion, do you think, so as to render it healthful?

A. Yes; I think it does so entirely. In Leipsic they say that such is the fact, even in the case of very quietly flowing streams; that a contamination of thirty-five parts of ammonia, which is three or four times more than the health limit, will disappear in a flow of three or four miles, or with great rapidity. The process is also hastened by the sediment which is swept into the river. Probably the fine particles of mud have a disinfecting action, besides acting as material for precipitation where the process is long preserved.

Q. That process of decomposition, oxidation, and deposition takes place more rapidly where the water is exposed to the air, of course, and is not enclosed in a culvert?

A. Very much more rapidly.

Q. So that passage through a culvert would not have the same effect?

A. No, sir. On the contrary, the passage through a conduit, I think, may expose impure water to increased danger, because it appears, from some of the observations that have been made, that the low organisms which are so dangerous do not always develop in open water, and there is some reason for thinking it probable that dangerous forms are developed in closed tubes when not developed in open water, and that the same organisms which in open water are innocuous may become very dangerous to health in passing through closed tubes. And I believe there was a case of such pollution, which did occur in our own experience, when the water possessed a very disagreeable constitution, some years ago, and it was found that the contamination arose in the pipes. These, of course, are matters concerning the development of these organisms which, as you are all aware, are very much in debate, therefore I would not express positive opinions about them.

Q. But, finding that our water is largely impure, we cannot expect that the simple passage through a closed and darkened culvert is going to deprive that water to any appreciable extent of its noxious qualities or impurities?

A. I do not think you can safely count upon it.

Q. You have not the sunlight and you have not the same conditions?

A. And, I think, another essential difference is the absence of green vegetation, the presence of which is very important, because it is the principal source of the development of oxygen, the constant renewal of which by plants is, I believe, considered by chem-

ists more important in the purification of water than is the oxygen absorbed from the air. Oxygen is present in minute quantities, but disappears in open water; hence the necessity of its constant renewal. I believe it is considered now that the influence of atmospheric air upon the purification of water is of less importance than has been assumed, and that the vegetation as a deoxidizing agent is more important than the direct action of the air. I made some inquiries, both of Professor Hoffman and of Professor Leeds, as to whether there would be any object in artificially aerating water in the passage from the storage-basins to the city, and they both — neither knowing the other's answer — said immediately not; that air could not be introduced into the water in sufficient quantity to accomplish purification, — that it would not pay for the expense.

Q. On the general subject of Boston's water supply, doctor, knowing the nature and extent of the complaints, have you any suggestions to make to this Commission as to how best to remedy them?

A. I do not think I wish to make any suggestions beyond what would naturally come of themselves from what I have said. That is, the desirability of establishing rules to prevent the present system of occasionally drawing off and cleaning; then the necessity of preserving the vegetation of the basins, and, if it ever becomes necessary to clean them, to do so by dredging, and in that case to allow the vegetation to start up again before the water is again turned into the system of water supply; and, also, the consideration of the possibility of using the soil-water in case an increase in the water supply should be deemed necessary. I think the other suggestions will appear of themselves.

Q. In relation to the subject of vegetation, if you should remove the soil from which vegetation would naturally grow, what would you deem essential as a substitute? Would you create artificial vegetation there?

A. No, sir; because vegetation will always develop of itself as soon as it is requisite. It will form in its own soil and constantly increase, so that if you have a clean bottom all you have to do is to leave it undisturbed. If you clean it off by dredging at the beginning, or during the hot season, the pond is exposed to putrefaction of the vegetation killed; but if you do so in the late autumn, then by next spring the vegetation would start up again.

Q. Then there is no danger to be apprehended from cleaning, provided the proper time of the year is chosen?

A. If the proper time of the year is chosen, and if you avoid killing off what you leave there.

Q. Well, suppose we clean the bottom thoroughly, remove all the alluvial soil and mould, etc., and do that very completely during cold weather, or at the beginning of cold weather, there is no danger to be apprehended from admitting the water there, and using that water the following summer, is there?

A. I think not, if the cleaning is really thorough. But it is almost impossible, in a majority of cases impossible, to have a really thorough cleaning.

Q. Even if you undertook it late in the season, and do not do

it perfectly, you would not have any vegetable organisms there under water?

A. Not during cold weather; but you might preserve a portion of the vegetable material until the next spring, and it would give rise to trouble then.

Q. Then you consider that the process even at any time is somewhat dangerous?

A. Yes; I think it should be reduced to a minimum.

Q. No new basin would be free from being exposed to the same thing?

A. When you start with a new basin, and clear away all the alluvial soil down to the gravel, you get down to a clean bottom, and you start with that. But if you have water turned in without removing the soil you have a great supply of matter which is partly in a state of preservation and partly decayed, besides everything which was killed when you drained off the water to clean up. And it is practically extremely difficult to clean off the bottom of such a basin completely unless you make the work on the bottom as you do when you first make it. There is the difference. Any one who has seen the actual cleaning out of a basin, and the condition of the water after it was let in again during the summer season, has seen at once that there was a very great contamination of the water.

Q. Is there any specific time during which these artificially prepared basins assume the character of natural ponds by process of self-purification?

A. I think in the course of a year or two they will come to be like natural ponds by self-purification.

Q. That is, by the process of solution, decomposition, and deposition, these decayed organic matters sink to the bottom and become harmless?

A. Yes, sir.

Q. And you would not consider that water injurious or deleterious to health?

A. No, sir. Without speaking of each individual case, I should expect that such water would be fit to use.

Q. Well, we have these conditions practically now, in our storage-basins?

A. No; because you have not the conditions of a natural pond. In a natural pond the decomposition of matter takes place as it is formed, and you find there that this matter is kept in a constantly moist condition, and, having undergone this decomposition upon the surface, it then remains in a tolerably constant condition. When such a deposit as that is converted into soil, as has actually occurred in meadows, you have again altered conditions, and you no longer have the conditions which existed when the meadow was submerged, because the exposed soil has been acted upon by worms, insect larvæ, moles, and other terranean animals, and they have deposited their faeces in it, and the whole nature of the soil is very different from the bottom of a natural pond.

Mr. SHEPARD.—As I understand, the Water Board now for some years have been removing the loam gradually in these basins

during the summer season when the water is low, so that in time they expect to get it all removed around the borders to a depth of from seven to twelve feet; and, from the remarks you have last made, I should consider you would assume that to be dangerous to the water supply?

A. I should think it was undesirable to do that during that season.

Q. Well, it would be at any time, would it, to keep continually drawing water from that basin?

A. The continual drawing of water from that basin, and the storing of it, I think, must increase the danger of pollution, because it is a question of solution from such a soil. Of course the rapidity of solution depends upon the extent of the exposed surface; and if the soil is dug up a great deal of it remains suspended in the water, and thereby the surface for solution is increased.

Q. Then would there be any other way than to shut off one of those basins, drain the water off, and clear the basin, and then let the water in to stand for some months before using it?

A. I should think that would be the best way.

Dr. BLAKE. — And to do that in cold weather?

A. Yes, sir.

Mr. SHEPARD. — And that is practically the only way, is it not?

A. I think so, — consistently with a due regard to health.

Q. And that would be done with comparatively little danger, and with great ultimate benefit?

A. Yes, sir.

Q. It has been stated by the engineers that the expense of that is going to be something very large. Do you think it is important enough to say that it should be done notwithstanding?

A. As far as I can judge, I should suppose it would be.

Dr. BLAKE. — You think, doctor, that the ultimate benefit following that thorough cleansing would justify the expense, even if large?

A. That would be my opinion. I only wish to have it understood clearly that I do not consider myself one of those who have thoroughly investigated the matter.

Q. Well, as a tax-payer, and having that stated to you as the result of scientific investigation, you would feel justified in authorizing such an expense for the benefit that you would personally derive from having a better supply of water?

A. Yes, sir ; that is so.

Mr. SHEPARD. — Are you of the opinion that the soil should be removed from the entire basin, even where the water is to be deep?

A. I should think that would be the best plan, unquestionably. I should hope to have my reservation noted, that I do not consider myself sufficiently posted. If I were to give advice which would be decisive, I should want to have some such opportunity as the Commission have enjoyed.

Dr. BLAKE. — Are you familiar with the possible sources of water supply for Boston?

A. Only roughly. I have no very minute familiarity with them.

Q. From your experience, from the experience of the authorities at Leipsic, and from your general knowledge of the surroundings of Boston, you think we would be justified in making the experiment of obtaining a supply of water by boring?

A. A supply of surface-water, that is, I should not recommend seeking for deep water, but soil-water in its ordinary sense, standing at a certain level below the surface. I should think you would.

Q. How deep would you consider it desirable to penetrate in order to endeavor to obtain water?

A. Not more than a limited number of feet.

Q. Fifty feet?

A. I should think fifty feet would be the outside limit. It might be desirable in making the investigation to make some borings which would go deeper than that, because the standing of the water does not depend upon the configuration of the surface. You might get upon a hill where you would wish to make a boring; of course that would increase necessarily the depth. But I should consider that advisable only in case an increased supply was necessary. I think our supply now is a very large one.

Adjourned.

BOSTON, Dec. 9, 1882.

WATER ANALYSIS,

SUDSBURY-RIVER WATERS, FROM BOSTON WATER COMMISSION.

[Figures express parts per 100,000 of water.]

Location.	Free Ammo-nia.	"Albu-mi-noid" Am-monia.	Chlo- rine.	RESIDUE.			Hardness.
				Fixed.	Vola-tile.	Total.	
Above Cedar Swamp Pond . . .	.0008	.0084	.21	2.90	3.00	5.90	1
Below " " " . . .	.0024	.0198	.56	4.00	4.40	8.40	1½
Above Junction of Cedar Brook	.0043	.0184	.32	1.40	3.70	5.10	1½
" Basin II. . . . .	.0011	.0192	.46	3.60	4.00	7.60	1
Dam II. . . . .	.0005	.0302	.52	3.70	5.00	8.70	1
Above Basin III. . . . .	.0037	.0194	.60	3.60	2.50	6.10	1½
Dam III. . . . .	.0005	.0290	.48	3.25	3.00	6.25	1
Service at Medical School, Feb. 3.	.0026	.0222	.48	3.50	4.10	7.60	1°

EDWARD S. WOOD.





